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The Commercial Factor in Power Plant Problems.

Few problems with which the engineer is called on to deal are more puzzling than some of those which arise in connection with power plant practice, and in particular those which are concerned with questions of the heat gain or loss due to various combinations of power plant elements or features. In the study of such problems much help may often be realized by the application of well known principles of business accounting, and by the treatment of heat energy by some method of ledger balances. As a general viewpoint from which departure may be taken, it will be found helpful to consider the power house as an isolated part of space, shut off from the rest of the world by the six walls of the building or room in which it is located, or by six imaginary planes forming a box and inclosing the plant. Such a method clearly grasped and followed up will serve to throw a flood of light on many otherwise obscure problems. The entire operation of a power plant is thus seen to consist in the inflow of a stream or streams of energy from the outside, flowing across or through the walls and into the inclosed space, while simultaneously streams of energy of one kind or another are also flowing from within outward, the special power house function consisting in a transformation of some character which a part of the stream of energy undergoes while within the inclosed space. The conservation of energy immediately gives us the general statement that when the station is working under steady conditions the total outflow must equal the total inflow. The more important of these various streams of inflow and outflow may be classified as follows:

Under inflow may be considered first, fuel; second, air, and third, water. Under outflow is to be taken, first, unburned fuel; second, heat in ashes; third, heat in smoke; fourth, mechanical work in the engine; fifth, heat in exhaust steam; sixth, heat carried away by condensing water, and seventh, radiation and conduction.

On the inflow side the cost of the fuel determines primarily the cost of input, while on the outflow side in the typical case the useful product is represented by the mechanical work in the engine. The general purpose of economic management is then to make the latter as large as possible for a given total input, or usually for a given amount of fuel. This means the reduction of all other items on the outflow side to their minimum values, and any proposition relating to power plant installation or policy, insofar as questions of thermal efficiency are concerned, must ultimately be reduced to test in this form. Simple illustrations of this will readily suggest themselves to the engineer.

More complicated questions arise in connection with various combinations of main engines, auxiliaries with varying rates of economy, feed heaters of the open or closed type, economizers, superheaters, the use of steam for heating or industrial purposes, etc. For such cases the application of the fundamental principles of business accounting applied to the concept of streams of energy, inflow and outflow, will serve as a powerful aid in forming a clear idea of the relations involved, and of the combinations best suited to the requirements of the case. For the improvement of power plant conditions two general methods are indicated: First, an actual reduction in one of the waste outflow streams; second, a change in the destination of a stream by virtually bending it about and bringing it, at another point, back into the general heat cycle, thus constituting in effect a closed cycle for this part of the heat energy.

The first method is, of course, similar to the decrease in some one expense account appearing on the books of a commercial enterprise, while the second is equivalent to the suppression of such an account by a transfer back into the business at another point; or in other words, to a series of transfers from one department to another in a closed cycle and without external payment at any point. Thus for illustration, if the exhaust from a feed pump has been led direct to the open air, such item is a direct constituent of outflow under heat in exhaust steam. If, instead, it is led to a condenser such change will suppress the heat in exhaust steam, and there will appear an item of reduced amount under the heat carried away by the condensing water, while the balance, heat in the feed water, will appear as inflow under water. The improvement has thus resulted from turning a part of outflow in heat in exhaust steam into a closed cycle, and thus making it again a part of the inflow stream so far as the boilers are concerned, yet not coming from outside the plant as a whole. Similarly, the change from a non-condensing to a condensing engine means like changes, but on a larger scale. Again, the use of an open feed heater into which the exhaust from auxiliaries is led, is seen to shut off the entire outflow from this source and to turn the heat into an internal or closed cycle. This condition will hold so long as the temperature of the feed water does not rise above the atmospheric boiling point. If the exhaust steam is greater in quantity than can be absorbed in the feed without rising to the boiling point, then a part of the feed will vaporize and carry off heat in this manner under radiation and conduction. On the other hand, with a closed heater passing the steam through on one side of the heating surface and the feed water on the other, a part only of the heat in the exhaust steam will be absorbed and turned into the internal cycle while the remainder will be expended under heat in the exhaust steam, as before. In comparison with the policy of passing the auxiliary steam into a condenser, the actual details of the case would be required in order to effect a judgment between the two.

A condition of special interest arises when steam is used for heating or industrial purposes as well as for power. In case the two demands are so proportioned that the industrial heat may be obtained from the steam in the engine exhaust, we then have the significant result of being able to utilize fully all heat energy which comes to the engine, and of thus leaving chargeable to the power account only the heat energy which is actually transformed into mechanical work. In other words, so far as the power account alone is concerned, we have the same result as would be given by a heat engine working with a one hundred per cent. efficiency. In order to realize this condition, it is obvious that the engine should be so selected with reference to its efficiency that the proportion between the heat transformed into work and that rejected in the exhaust will bear the value desired for the ratio between mechanical work and industrial heat. An engine with less economy will reject more heat than can be utilized for industrial purposes, and some part must, therefore, be rejected as a waste or loss. An engine of higher economy will reject less heat than that required for industrial purposes, and the shortage must be made up by live steam from the boiler. While this may leave the general heat balance the same as before, it will mean the installation of a more economical engine than is needed and hence the expenditure of an additional amount of capital for which there is no corresponding return in the way of increased plant efficiency. Such conditions may, therefore, well justify the installation of an engine of very low efficiency where under other conditions the highest efficiency would be sought.

These various relations are only illustrative of some few of the many cases which may arise and which may with advantage be studied from the counting house viewpoint. Interesting parallels between such cases and familiar operations in counting house practice might be worked out in detail, but this is scarcely necessary. The important point is not so much the parallel or analogy in detail as the development of a habit of mind which instinctively applies the underlying principles of the counting house to problems of engineering which necessarily involve questions of income and outgo, of balance, profit, loss and similar items. In all these questions the engineer is concerned with the quantitative handling of energy in problems bearing a close analogy with those with which the accountant is concerned. For such problems it is fair to say that the accountant has perhaps developed his viewpoint more keenly and his methods more perfectly than has the engineer, and the latter may often well afford to copy from the former.

The Electrolysis of Pipes.

The article on the electrolysis of pipes by Mr. Putnam A. Bates, elsewhere in this issue, is an interesting commentary on the subject from the electrical point of view. The general conditions that govern electrolysis are well known; whenever on a pipe system there is a difference of potential between a pipe and the earth or other pipes, there is the possibility of trouble from electrolysis. The mischief is done at the point where the current leaves the pipe, and the amount of electrolytic corrosion is proportional to the amount of current. Whether a given difference of potential produces a perceptible flow of current depends, however, entirely on the surroundings, as Mr. Bates clearly shows. A cast-iron pipe, for instance, might even be in a metallic trough, and if the material between were a few inches of dry sand there would be no perceptible current and hence no electrolysis. If, on the other hand, the intervening material were the muck of an old street, which is relatively a very fair conductor, there would be a destructive flow of current even with only a volt or two actual difference of potential. Potential measurements, therefore, indicate only potential danger, and show the danger district where the managers of water and gas works must be alert to detect early indications of trouble, so that serious damage may not result. The actual current flowing out of the pipe is seldom easy to determine, but in studying electrolysis an effort should always be made at actually measuring this quantity under average conditions.

Granting the existence of a current flowing from the pipes to other conductors, the amount of actual damage done depends on conditions existing locally. A length of heavy water main may permit the outflow of considerable current without noticeable damage, if the flow is uniformly distributed over a large area. If, on the other hand, the area of outflow is restricted, the pipe may be perforated in a comparatively brief period. The real question is the current density in the region of outflow from the pipe. This is fortunately small in most instances. Should it rise to half an ampere or an ampere per square foot, there would probably be very rapid perforation of the pipe, since the action generally starts in spots, producing the well-known pitting effect. It must not be supposed, however, that this pitting, if found upon a pipe, always determines the cause of injury as electrolytic. Pipe not uniform in surface texture and buried in earth generally far from uniform in texture will occasionally show distinct pitting due to ordinary chemical action of corrosive elements in the earth. To be safe in ascribing a given case of distinctive corrosion to stray currents, one must be certain of their presence. Another important matter in determining corrosion of pipes is the uniformity of the condition of the earth around them. As a rule, the surface of pipes buried in a city street is rapidly affected at first, whether electrolysis is or is not present, a coating of rust and the debris of corrosion being formed which is, to a material degree, protective against further injury. Long-buried pipes appear at times to be covered with a sort of natural cement coating.

If the condition of the earth is fairly uniform, further corrosion proceeds very slowly. The greatest damage is found in places where there is frequent change in moisture, where the debris formed is periodically dissolved or washed away, as at the surface line in the case of iron posts. In cases where there is considerable stray current and resulting electrolysis, immediate remedial measures should be applied. There is no general cure for such conditions. The thing which could be considered a panacea, the double-trolley system, is held at present in this country by electric railway officials to be inadmissible. The large conducting power of the rails is regarded by them as far too valuable to be thrown away even were the double trolley less troublesome in operation than it is. The better the rail return, however, the less current will stray away from it, and for its own sake in saving energy the electric road should keep its bonding up to the highest pitch of efficiency. Beyond this it is generally held that the electrolysis evil is best treated symptomatically on the basis of tests showing what and how great the stray currents really are. Jumpers and return cables judiciously placed will greatly reduce the danger at certain points, and sometimes a little attention to drainage may be of considerable assistance in cutting down the distinctive flow of current. Most electric railway engineers will disagree with Mr. Bates' position on double-trolley and conduit roads as remedies for electrolytic evils, and contend that these systoms add enormously, sometimes prohibitively, to the cost of railway construction, and that, so far from the results to the railway being well worth the additional outlay, both systems are costly to maintain and less reliable in service than the ordinary single trolley. Money spent in improving the track circuit is, however, always well spent, and by this and carefully planned remedial measures the practical danger from electrolysis, ought to be greatly reduced. It is gratifying to observe, nevertheless, that Mr. Bates has placed himself on the side of the small but influential group of electrical engineers who have acknowledged the double trolley to be the only really satisfactory remedy for this serious source of destruction to sub-surface pipes.

The Trend of Technical Education.

The development of technical education in the United States during the past fifteen or twenty years has been particularly notable in two directions; in the great growth in numbers of students and in the increase in the number of schools providing technical courses of a satisfactory grade. There has also been some advance in the professional character of the instruction in those schools which at the beginning of this period were already offering well-developed courses; but an examination of the catalogues of such schools will show that for the past ten years at least the changes in this direction have not been great.

Twenty years ago many of our now full-fledged technical schools, in particular those connected with State universities and agricultural colleges, provided so-called courses in civil and mechanical engineering in which all the technical instruction offered could be covered in little more than a single year's work. The balance of the time, after providing for the necessary methematics, science and languages, was filled up with history, or philosophy, or mineralogy, or whatever was most available in the particular school. One or two men composed the engineering faculty and taught the mechanics, surveying, drawing and such advanced studies as their time would permit. The number of schools then giving a really adequate technical course could almost be counted on the fingers of one hand.

As a result of the development of these weaker schools of two decades ago a large number of institutions have now been brought to a nearly equal basis and the engineering curriculum has to a very considerable degree become standardized. It may fairly be said that, considering the conditions surrounding the great majority of our engineering schools in the matter of entrance requirements, a substantial agreement has been reached concerning nine-tenths of the work which should be given in a satisfactory engineering course. The development in the future of new or weak schools will probably be in the direction of the standard already set and will be comparatively simple and rapid; but the development of those now among the best will be slow and will involve many problems and difficulties.

The future advance in technical education will apparently be along two rather divergent lines; one in the direction of a broader and more general training and the other in the direction of specialization in applied science, involving advanced study and research. In either case the work will be based on broader lines. There is evidence that in some schools there has been in the past two much emphasis laid on the expansion of purely technical work, but there is now a decided tendency in the opposite direction. In the courses in civil engineering, for example, more instruction is being given in electricity and steam engineering; in the courses in mechanical and electrical engineering more of civil engineering subjects are taught; excessive requirements in shop work have been reduced; much more attention is being given to improvements in the teaching of the more general studies—English, mathematics and the sciences; and such studies as economics and business administration are appearing in the courses. A better understanding exists among educators, and engineers as well, in regard to the limitations of the college in the teaching of subjects involving mere practice or empirical design, although there still exists an occasional demand on the part of some employer for a product from the school all ready made for his special and exclusive use.

The movement towards a broader education is in the right direction. There are few studies in our standard engineering courses that can well be displaced or can readily be thrown back upon the preparatory school, but there will certainly be a gradual, though slow, increase in entrance requirements and an increase in the proportion of technical students who will first have had a college course, thus permitting a general increase in the period of time devoted to a preparation for the profession. The engineer of the future will be a better and more broadly trained man than his brother of the present generation.

Executive and administrative positions which the engineer is filling to an increasing extent and which for some reasons he is especially well qualified to fill, require something more than a knowledge of physical laws and constructive details. They require above all a knowledge of men and a breadth of view extending beyond the narrow scope of the mechanical problems involved. This view is often urged by many of the older engineers of the profession and is shared also by the best teachers in our technical schools, especially among those teachers who are at the same time engineers of considerable experience. That an effort is being made in many of our best schools to secure this breadth of view is evident from the very extended discussion of this subject at the recent meeting of the Society for the Promotion of Engineering Education. Apparently the only question on which there was doubt was with reference to the best plan to accomplish this very desirable end.

It seemed to be the general opinion that formal courses of general study will not be required to accomplish the desired results. It is not clear, however, why the general educational training of an engineer should not be as systematic to be effective as his subsequent professional training. While it is true that some educational value must attach to incidental instruction in connection with subjects more technical, it scarcely seems reasonable to expect that the best results can be reached in this manner. The Engineering Record is inclined to support any broad view of engineering education which will fit the young graduate to become the best type of professional man, which means an engineer possessing those broad educational qualifications enabling him to take the position of an accomplished man as well as an efficient engineer. This journal is further of the opinion that provision will be made in the near future in a greater number of engineering schools than at present whereby an increased number of students will enter the professional school equipped with a broad general education given by the usual college training, thus freeing the professional school of all instruction work except in purely technical subjects. This tendency should be stimulated by every means in the power of engineering educators. It is the direction in which the best educational efforts lie. Such an educational system is the only one by which the profession of engineering can attain to the advanced position to which its importance and its high character entitle it.

Power Distribution for Cities.

If the recent developments in electric power station practice are followed to their logical conclusions, it becomes apparent that there is still a long space to be spanned between the real and the ideal. A modern city has vast and varied requirements in heat, light and power, which thus far in spite of all the progress that has been made are far from being met. Electric central stations have grown from small and isolated stations to colossal plants serving an immense territory, but there still remain huge gas plants of which the service overlaps the electric service, and beyond these there is a vast consumption of coal locally for purposes which the gas and electric plants could better fulfill. In spite of the gas engine and the electric motor, the pall of smoke over the city grows year by year darker and more oppressive and the struggles against it are fruitless. There have been consolidations and mergers of light and power companies which have borne no fruits save for the promoters. Not yet has a captain of industry appeared with so great resources and so wide a grasp of the larger strategy of the situation as to fight successfully for a combination that implies a revolution in methods as part of the battle for dividends. It may be well to briefly point out some of the unaccomplished things that are from every point of view worth the struggle. Every city needs in rapidly increasing amounts light, heat and power. The first can be successfully provided by electricity or by gas, with the hygienic advantage in favor of the former; the second cannot be under existing conditions economically furnished by electricity, can be but is not, furnished by gas, and is actually dependent on the burning of fuel, generally in a rather uneconomical way. Power can be furnished most commercially by electric motors, quite satisfactorily by gas motors, and is actually produced mostly from fuel.

Now there is no valid economic reason why between gas and electricity the burning of fuel with its attendant smoke, waste and trouble cannot be made absolutely needless. In other words, a combination power plant on a large scale can do the whole work on an economical basis if advantage is taken of the various factors which enter the situation. Let us suppose, for example, that a merger is effected between the companies producing gas and electricity in and about a city like Philadelphia, or Boston, or New York. Its purpose is to get the whole market and to suppress the local burning of fuel. To this end a great combination plant is erected at a point most advantageous for the securing of fuel, and the existing plants are shut down or used as auxiliaries. The first new step is the production of cheap fuel gas, with the ultimate abandonment of illuminating gas in view. The coal is turned mainly into gas and distributed for heating and large power purposes, while the electric plant is a combination, let us say, of huge turbines and of gas engines between which the load can be distributed in the most economical way. In summer when the heating load is small the gas engines can be made to bear the brunt of the work, and in winter when the load on both systems is heavy, both will be driven at full head, with the steam units all at work. Auxiliary electric stations at all necessary points can be driven by the fuel gas supply if necessary, the intention being to take up all the small power by electric motors and to do all lighting electrically save what can be done by mantle burners worked with fuel gas.

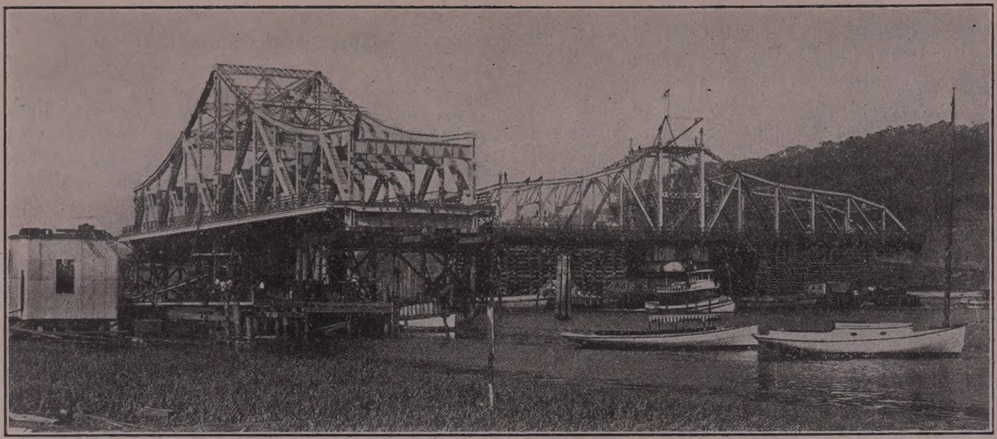
With the enormous production implied by undertaking general heating by fuel gas it is pretty clear from actual experience that it could be furnished at a figure that would make the crude use of fuel uneconomical. Even now for cooking and minor heating purposes gas is cheaper than coal, and its current price is kept needlessly high by the present custom of making it rich enough for use as an illuminant with ordinary flames, in themselves most inefficient as light producers. Likewise electric light, if the market is on a large enough scale, can be brought to a price that will enable it to be used universally. There are now many cases in which the gas and electric services of a city are under a single management, but so far as The Engineering Record has been informed there is not a single one in which they are worked together in a way sufficiently broad to secure the full benefit of the combination. It is easily conceivable that, given a guarantee of prices sufficiently low, a municipality would find it advantageous so to restrict the use of coal within its limits as to ensure a practically universal use of gas and electricity. As to actual figures, one can only extrapolate from the present facts. Working in a large scale from cheap coal electrical energy can certainly be put upon the bus bars at less than half a cent per kilowatt hour if the load factor can be kept at a point such as fairly can be expected under the assumed conditions. Fuel gas likewise can be put in the holders under similar conditions at a price which has been estimated as considerably below twenty-five cents per thousand feet. Each of these figures must have added the costs of distribution and the capital charges, and is also subject to diminution on account of quantity, and of unity of administration. It is perfectly safe to say that both gas and electricity under these conditions could be sold at a price beyond the competition of locally utilized coal. In some situations coking coal could be used to great advantage, giving still another element of interchange between the gas and electric plants and an opportunity for the gradual abandonment of ordinary fuel via cheap coke. The known possibilities of distributing electricity and gas make the programme here outlined an entirely feasible proposition if undertaken on a large scale along broad lines. In fact, the situation sketched appears only to await for its development the advent of a man of sufficiently broad calibre to appreciate fully and coordinate properly all of the financial, engineering and public factors involved, who can obtain a respectful hearing from capitalists, and to whom stock-jobbing motives will not be attributed.

Notes and Comments.

The Manufacture of Tantalum, one of the hardest metals known, into sheets and bars, is now practiced in Germany by Siemens & Halske Co., by the squirting process, the material in its original powdered form being mixed with water and gum tragacanth and then successfully forced into rods and shapes as desired.

A Steam Regenerator System for utilizing the exhaust steam of reciprocating engines in low-pressure steam turbines is being installed at the Irondale steel works of the International Harvester Co. at South Chicago. The regenerator, which is built according to the Rateau system, and is the first to be installed in this country, provides for the storage of the latent heat of excess exhaust steam as it comes from the reciprocating engines, giving it up when the supply of exhaust fluctuates below the requirements of the turbines. The regenerator consists of numerous massive cast-iron pans filled with water and arranged vertically in an enclosed cylindrical steel receiver.

The Interpretation of Laboratory Experimental Results for practical purposes often calls for the exercise of experience and judgment that are not considered necessary by those who are in charge of affairs. The fact that uniform results can be obtained continuously in the laboratory is a pretty certain indication in some kinds of work that they can be duplicated on a large scale by a skilful chemical engineer. Some of the achievements in this line afford remarkable examples of the development of a technological process by laboratory research. Nevertheless this is not true of most branches of engineering, any more than the development of certain electrical apparatus by mathematical means is proof of the uniform necessity of mathematics. In civil engineering particularly, the laboratory may become a source of serious error if all the conditions affecting the experimental results are not carefully considered. This is well shown by the marked difference between laboratory and field experience with wet and dry concrete mixtures. It is the general experience in laboratories that small compression test-pieces of dry concrete show a higher compressive resistance and greater impermeability to water than those of wet mixtures, yet the testimony from the field is largely to the opposite effect. The reason for this is readily ascertained. The small volumes of concrete made up in the laboratory are prepared under conditions which develop the cementing properties of the mixture to the utmost degree. The materials are properly proportioned, the water added at just the right time in the right amount, the ramming of the concrete into the molds is thorough, and the curing is done under the best conditions. In the field, this degree of care is not practicable, and consequently the wet mixture gives better results than that conforming more closely to laboratory methods. This particular instance of the effect of field conditions on reversing the indications of the laboratory is of special interest just now because some makers of cement-block machinery have put forth compilations of laboratory tests to prove that dry mixtures, such as can alone be used in block machines, furnish better results than wet mixtures. It is true that a few hollow concrete blocks that have been tested have developed high ultimate resistance to crushing, but a protest must be made against the use of such results as typical of the average product of this industry. As a rule, the blocks are not as strong as first-class brickwork nor are they any more damp-proof, their advantages lying in other features.



Old and New Draw Spans Ready for Transit.

THE REPLACEMENT OF THE BROADWAY BRIDGE OVER THE HARLEM SHIP CANAL.

The original bridge across the Harlem Ship Canal, at Broadway and 221st St., Kings Bridge, New York City, was a three-span structure about 483 ft. long between the faces of the abuments, which included a draw span 26 ft. high in the clear above mean high water with two clear 104-ft. openings for navigation, and two lattice girder approach spans 104 and 106 ft. long and 26 ft. in the clear above high water. The structure had a total clear width of 50 ft. and carried a highway and two sidewalks. The substructure consisted of two intermediate piers, a massive pivot pier and two heavy abutments of handsome stone masonry seated on the solid rock which forms part of the canal bed at this point. The superstructure was of single deck design, with a pin-connected swing span about 45 ft. deep mounted on a rim bearing turn-table and operated by steam power which opened it in about 15 minutes. It was of modern design and excellent construction and was built by the King Bridge Co., under the direction of the department of Public Works, N. Y., Professor W. H. Burr, consulting engineer, and was opened for traffic June 17, 1896.

Since that time the structure for the Rapid Transit Railroad has been completed to the ship canal, which it must cross in order to provide for the proposed extension of the service to Van Cortlandt Park. At this point the tracks of that road are carried on an elevated railroad structure and it was decided to continue them across the river on the Broadway bridge. The existing bridge, although comparatively new and entirely adequate for the requirements it was designed to meet, was not calculated to sustain the additional service for the Rapid Transit trains and it was decided to remove the old superstructure to 207th St., where it will be used as a simple highway bridge across the ship canal. It was also decided to replace it at the original site by a new double-deck structure with spans of substantially the same length and width, but of a much greater capacity, designed to carry three railroad tracks, two electric-car tracks, the highway and two 10-ft. sidewalks cantilevered outside of the trusses. The old substructure was of sufficient strength and of suitable dimensions to support the new superstructure and has therefore been adapted for it without material modification.

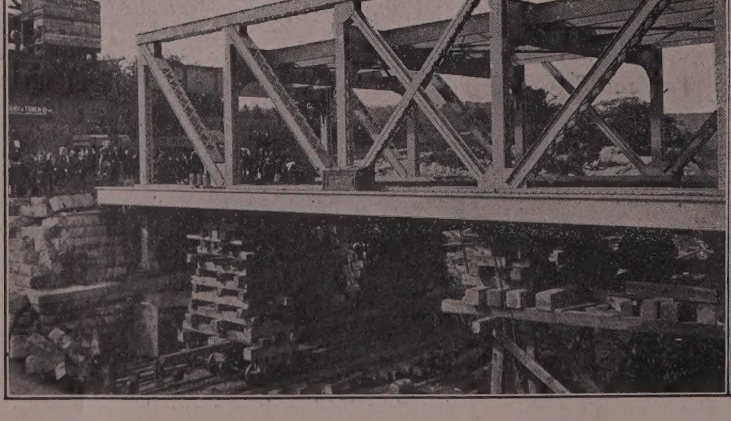
It was required that the replacement of the bridge be effected without serious interruption to vehicular traffic and with the minimum obstruction to navigation, so it was therefore determined to erect the new spans at convenient positions nearby, and float them to their final positions simultaneously with the floating of the old spans to their new substructure at 207th St. This operation is essentially similar to that frequently employed for the erection of draw bridges and some other spans, but has been modified by several unusual features which give additional interest to the method and the details of the operations.

The superstructure was fabricated by the American Bridge Co., who built it chiefly at their Pencoyd plant and owing to a delay in securing some of the material, completed the approach spans several months in advance of the draw spans. These were therefore erected and replaced the old ones last fall, while the new draw span was not put in its final position until a few weeks ago. The new approach spans have riveted Pratt trusses about 20 ft. deep and 39 ft. apart on centers and are about 100 ft. and 112 ft. long, weighing respectively 580,500 lb. and 656,500 lb. with rails, ties, etc., complete.

The 112-ft. span at the north end of the bridge was erected on shore, about 150 ft. east of and parallel with the bridge. It was assembled on sets of cribbing about 15 ft. high as indicated in Diagram 1. The cribbing at the shore end was built on the decks of ordinary flat cars running on tracks in the planes of the trusses. The river end of the span cantilevered one panel beyond the last crib, overhanging the water a clear distance of about 17 ft. beyond the bulkhead line. All materials were handled by a single stiff-leg derrick with an 82-ft. boom of 25 tons capacity, operated by a Lidgerwood hoisting engine. After the span was entirely completed, a 30x100-ft. barge, 10 ft. deep and partly filled with water ballast, was floated under the overhanging panels of the span transverse to it, and crib work built up from the barge to the ends of the trusses.

On a rising tide the water ballast was pumped out and the buoyancy of the barge lifted the end of the span sufficient to throw the weight of the other end on the trucks and release the intermediate cribbing. Two sets of piers next the trucks were removed, as shown in Diagram 2. The span was then moved in the direction of its own axis, one panel length, supported at the ends by the barge and the trucks and clearing the two remaining sets of intermediate cribbing. It was held in this position while the water ballast was admitted to the barge, lowering the outer end of the span until it again rested at the two center panel points on two sets of crib work, with the two end panels overhanging the river, as shown in Diagram 3. The barge was then moved in close to the shore and trestle bents erected on it engaging the lower chords of the trusses at the second panel points, as shown in Diagram 4.

The trucks at the other end of the span were removed and the tracks were taken up and revolved 90 deg. to a new position parallel with the bulkhead line. The trucks were replaced on them under the second panel points, and cribbing built up as before to engage the floor beam at that point, as indicated in Diagram 5. Water ballast was once more removed from the barge and on a rising tide the bridge was lifted clear of the intermediate cribbing and supported again on the barge and on the trucks. Tackles operated by two hoisting engines were then attached to it and it was moved at right angles to its axis to its final position on the sub-structure on the old bridge where it was seated by admitting water ballast and jacking down on the trucks.



New North Approach Span on Trucks and Barge.

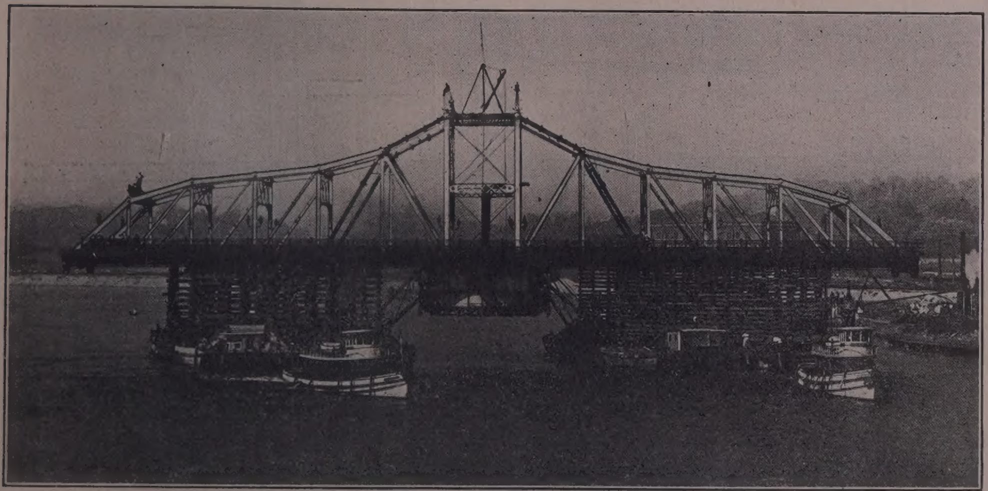
New South Approach Span on Oblique Tracks.

In the meantime the old span had been lifted from its seat by a barge placed under the river end and by jacking on a pair of trucks running on a single track parallel to the bulkhead line. This span was hauled away from its old position in the same manner as the new span was moved and simultaneously with it, so as to vacate the seats on the old substructure, which the latter afterwards occupied, the total operation of displacing the old span and seating the new one in its place only occupying a half hour and requiring a force of about 30 men.

On the opposite side of the river it was necessary to erect the south approach span in the position indicated by the general diagram, so close to the old bridge that there was not room there to move it far enough out from shore to engage the seats of the river pier. Therefore, it was first moved away from the old span in a direction diagonal with its axis until the river end was carried out the required distance, after which it was moved paralled with its own axis to displace the old span. The span was erected on cribbing in a manner similar to that described for the north span, with the river end overhanging the bulkhead line less than one panel length.

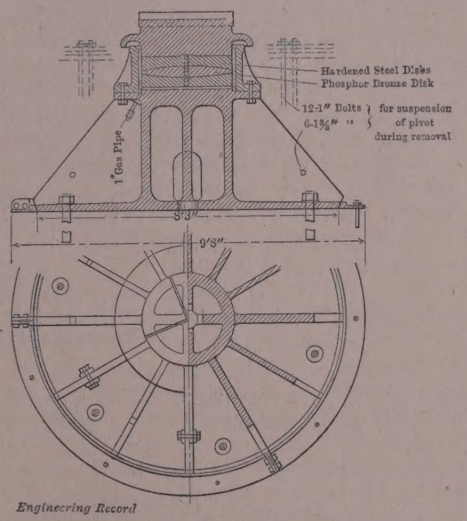
The pedestals at the shore end of the span were each supported on cribbing built up from two flat cars running on tracks diagonal to the bulkhead line, as indicated in the diagram. A barge was placed partly under the river end of the span which was supported from it by cribbing, and the span being lifted by a rising tide and the removal of water ballast was raised sufficiently to clear the intermediate cribbing and was moved in the direction of the diagonal tracks until it and the barge occupied the second position, indicated in the diagram by dotted lines. A second barge partly filled with water ballast was then floated under the span between the first barge and the bulkhead line in the postion indicated by the diagram.

A temporary track, not shown in the diagram, was then laid from the new span to the old bridge parallel with the bulkhead line, and flat cars on it were placed under each truss of the new span and crib work built on them to engage the latter. Water ballast was admitted to the first barge, and on a falling tide the span was lowered to take bearing on the new cars and on trestle bents built up from barge No. 2, thus releasing the first barge and the first set of cars. The bridge was then moved parallel to itself until it displaced the old span on the old superstructure.

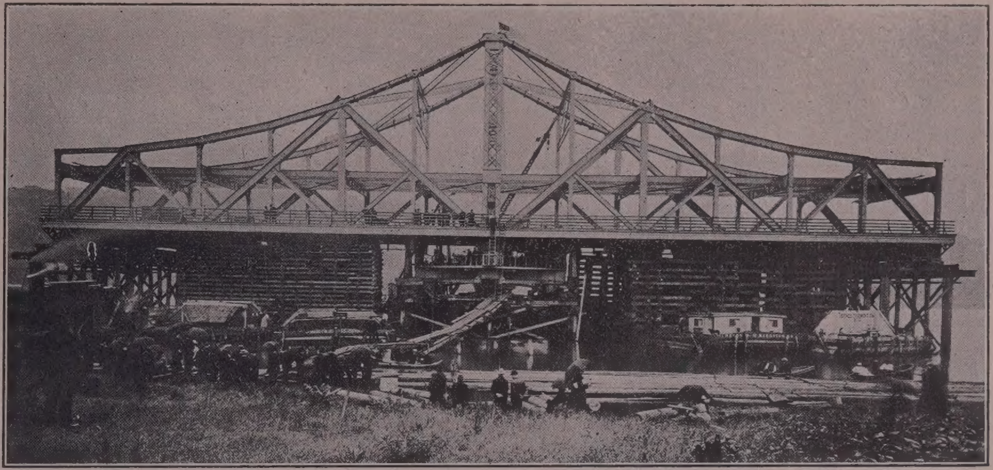


Removing Old Swing Span With Drum and Pivot Suspended.

The old span was simultaneously moved in the same direction to a position just clear of the opposite side of the old bridge, being supported in a similar manner by a barge and by flat cars on the tracks parallel with the bulkhead line. In this position only the shore end of the span was supported on land, therefore crib work was built under the second panel points of the trusses and the outer end of the span was lowered by water ballast in the barge until the trusses took bearing on top of the crib work and revolved the other ends upward a small amount, releasing the crib work and cars at that point. These were removed and tracks in the planes of the trusses were constructed, the flat cars placed on them and crib work built from them to engage the end of the span.



Center Bearing Pivot and Pivot Ring for New Swing Span.



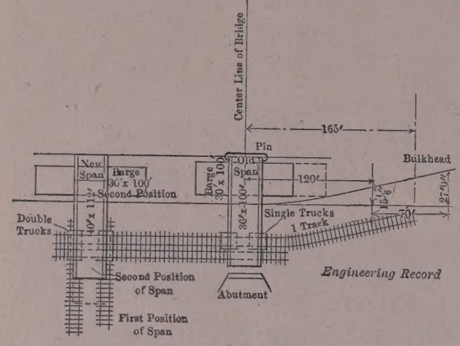
Lifting New Swing Span From Falsework.

The water ballast was then removed from the barge and on a rising tide the outer end of the span was lifted until the shore end took bearing over the cars and released the intermediate cribbing. The span was then moved on shore in the direction of its axis until the center of gravity was within the bulkhead line and the shore end encountered the trestle work supporting a coal track used by the Rapid Transit Construction Co. In this position the span was theoretically stable, but it was not considered prudent to concentrate so large a portion of its weight close to the edge of the old pier where the bulkhead timbers were thought to be somewhat decayed, so for that reason the obstructing trestle work was removed, the tracks were extended and the span was moved farther back so that the portion overhanging the bulkhead line was reduced to one panel. An additional pier of cribbing was then built under the span near the shore end and on a rising tide the span was lifted sufficiently to allow a new bearing to be provided over the cribbing nearest the river. On the falling tide the barge was released and the shore end of the span was given bearing on the second set of cribbing. The flat cars were released and the span was left for several months in this temporary position until it was convenient to reload it on barges and move it about a mile down the canal to its new site.

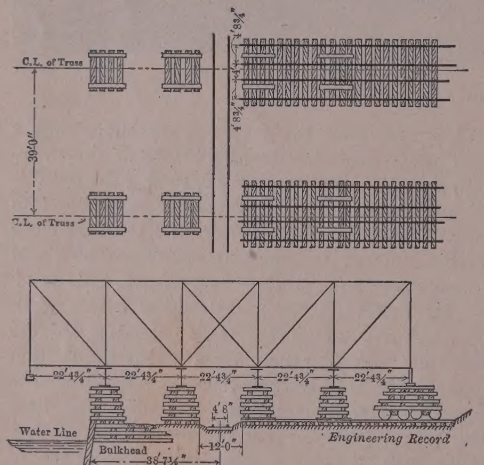
All the members for the pivot-bearing girders and the center panels and center posts of the pivot-bearing draw span were assembled and match-marked at the bridge shop at Pencoyd, so that later on they were erected with the minimum difficulty on pile falsework in the ship canal parallel to the bridge axis and about one-half mile distant from it, the bottom of the canal near the bridge not being suitable for the erection of falsework there. The shop fitting and trial operation of all of the operating mechanism and the center panels of the span assured accurate fitting and greatly facilitated the erection in which no expense was involved for fitting or altering the structure.

The span was assembled by a derrick boat belonging to the contractors, which was equipped with an A-frame and an 82-ft., 20-ton steel boom which handled all of the members except the 30-ton transverse girders which were handled by the lighter; the maximum weight of the other members was 13 tons. The span was thus erected very advantageously at a total cost not exceeding that which would have been incurred for the construction of an ordinary traveler. It was erected about 31 ft. clear of the water in four weeks, inclusive of the time required for installing the machinery. Additional time was required to complete the driving of 125,000 ⅞-in. and 1-in. field rivets, which were driven by Chicago pneumatic hammers operated by air furnished by a De La Vergne compressor.

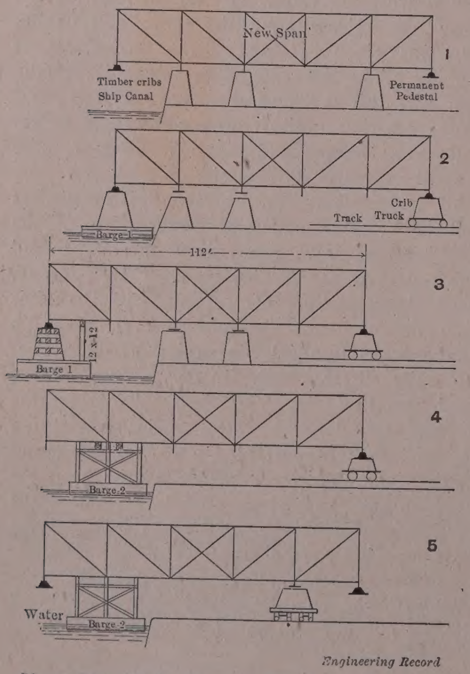
After the span was completed six of the seventeen pile falsework bents intermediate between the center and ends were removed and in each of the two wide panels thus vacated were placed on June 6, two 32x100-ft. barges 10 ft. deep, rented from the North River Towing Co. The barges of each pair were fastened close together side by side with the end of one projecting about 10 ft. beyond the other. On them were built falsework cribs made with long 12 x 12-in. timbers continuous across both barges and carried up to a height of about 24 ft. above water level. The barges and crib work were secured in the required position by diagonal timber braces and cables. The span was swung to a position making an angle of about 30 deg., with its former position, and on a rising tide water ballast was pumped out of the barges with two 8-in. centrifugal pumps and eight steam ejectors. The corresponding buoyancy of the barges lifted the superstructure clear of the substructure and the center distribution girders, center wedges, wheels, pivot and turning gear having all been carefully secured to the girders, were removed with it on June 16.



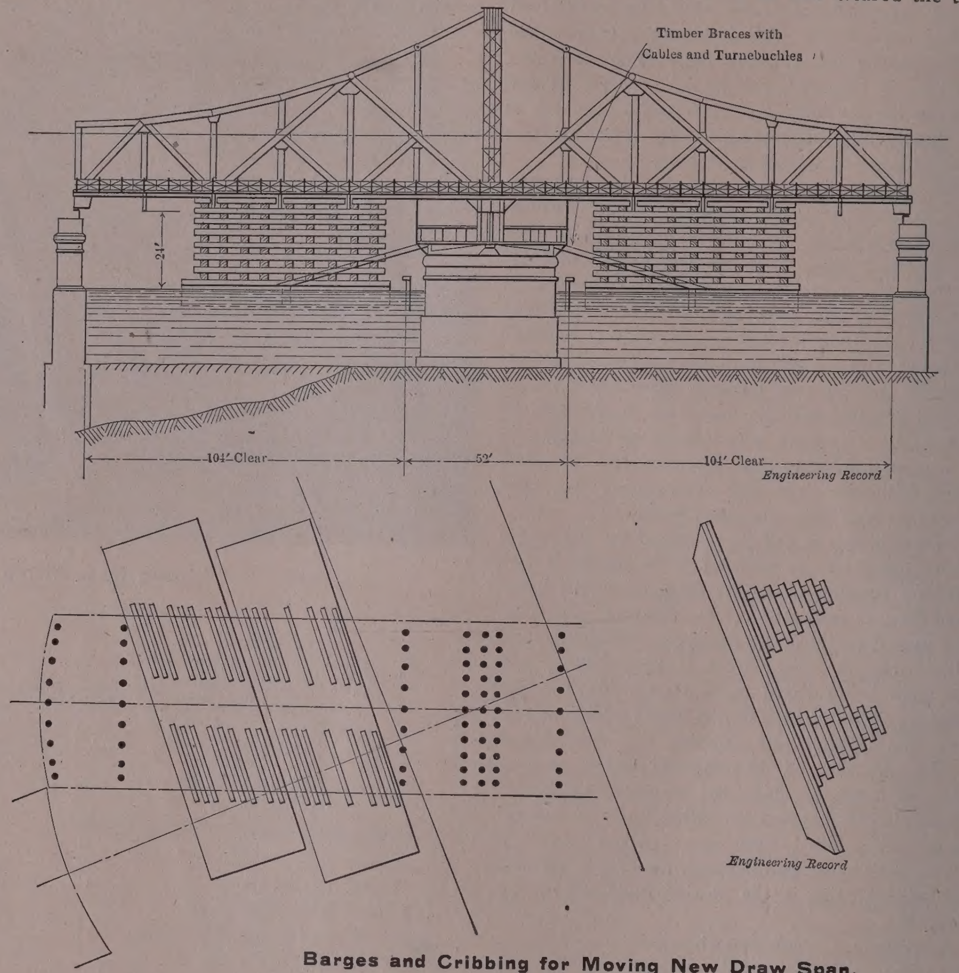
Tracks for Shore End of Old and New North Approach Spans.



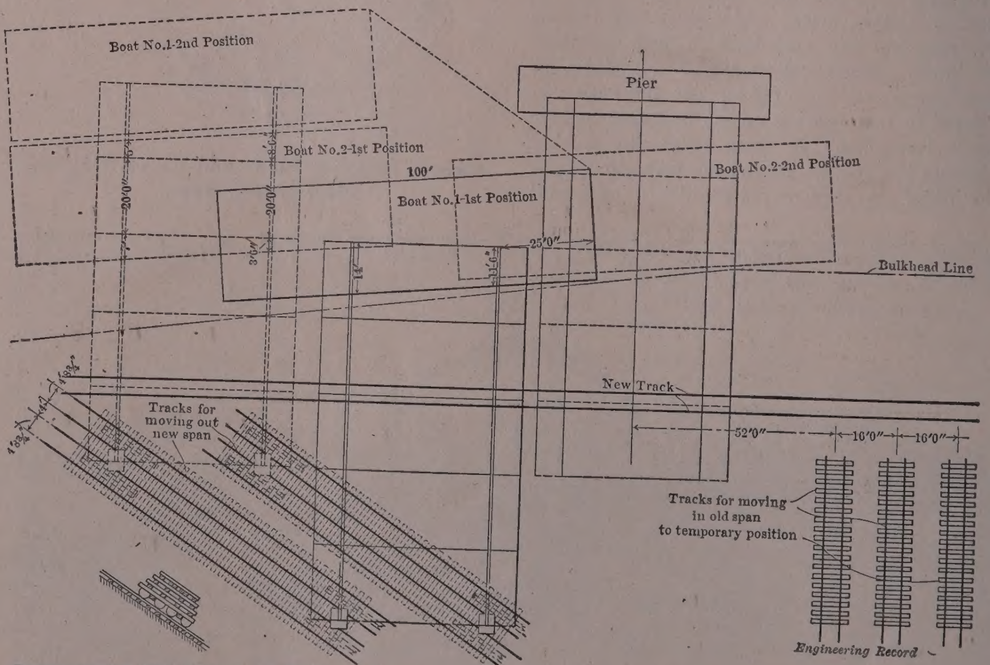
Cribbing for New North Approach Span.



New North Approach Span on Barge, Truck and Cribbing.



Barges and Cribbing for Moving New Draw Span.



Successive Positions of Barges Loading, Moving and Unloading New South Approach Span.

Meantime similar pairs of barges had been placed under the old swing span and provided with crib work engaging the lower chord panel points. At 10:30 A. M. of June 14, on a rising tide, pumps were started to remove the water ballast in these barges and at 2:30 P. M., the spans had been lifted 18 in. and cleared the top of the pivot pier. At 2:45 P. M., it was towed transversely away from the original site, carrying with it the drums, track and other turntable construction as described for the new span. At 3:43 P. M. it was brought over its pier at 207th St., and water ballast was admitted which at 8:15 P. M. landed it and released the barges. At 10:17 P. M., with a steam pressure of 40 lb., it was swung through an arc of about 90 deg. and left in a position parallel with the axis of the canal until such time as the remainder of the piers are built, at this point, and the other spans are placed on them so that the bridge can be put in service.

As the stresses developed in the old trusses during transit while supported on the barges were different from those for which it was calculated, some of them being reversed, two panels of the top chord were each reinforced by five pieces of 8 x 12-in. timber packed closely between the eye-bars and clamped in position by side pieces and tie bolts tightly screwed. The bottom chord was similarly reinforced with 6 x 18-in pieces, thus enabling the truss to endure the temporary stresses without injury.

In order to center the old pedestal on the new pivot pier at 207th St., a special sectional cast-iron ring was bolted in advance to the top of the pier. It was made with an inner conical surface accurately turned to engage the corresponding surface of the pedestal casting, so that when the latter engaged it within 2 in. of correct center, it would draw it to the exact position as it descended to bearing on the masonry. The old span was towed nearly a mile with the tide by four steam tugs and the new span was erected by a force of only five bridge men and about 20 laborers under the direction of Mr. E. F. Terry, president, and Mr. John Sullivan, superintendent of the Terry & Tench Co.

The total weight of the new swing span is about 1,795,000 lb. exclusive of the buckle plate floor, that of the old being about 1,218,000 lb. The total cost of the bridge improvement exclusive of the establishment of a bridge at 207th St., is about $260,000, of which $30,000 is paid by the New York Central & Hudson River R. R. Co., for lengthening the approach spans 12 ft. at one end and $13,000 is paid by the Metropolitan Street Railway Co. for widening the structure 5 ft. and laying two street car tracks.

The bridge was designed under the direction of the Rapid Transit Railway Commission, Mr. Geo. S. Rice, chief engineer, and Mr. Alfred Craven, deputy chief engineer; Mr. C. V. B. Powers, division engineer; Mr. Sverre Dahm, general inspector of designs. The general contract was awarded to the Rapid Transit Subway Construction Co., Mr. George H. Pegram, chief engineer, and Mr. A. S. Berquist, assistant engineer in charge of metal construction. The erection was done by the Terry & Tench Construction Co., who also operated the bridge for 30 days after the draw span was put in service. The bridge is now in very successful operation and the wedges can be pulled and the latch drawn in 30 seconds, the total interruption of traffic necessary to swing the span being only 4 minutes. The bridge was only out of service about 56 hr. during the replacement of the draw span and about 5 minutes for the south approach span and 30 minutes for the north approach span during the replacement. The longer interruption for the north approach span was due to the necessity of stopping to adjust the track.

A RECENT TEST OF PRODUCER GAS POWER EQUIPMENT in the city electric light plant at Algona, Iowa, by the Iowa State College Engineering Experiment Station, a fuel consumption of 1.511 lb. of coal was shown with a brake load of 40.1 h.-p. At 82.7 brake horse-power the fuel consumption was reduced to 1.157 lb. at a load of 156.9 h.-p. to 0.999 lb. of coal per brake horse-power. The producer is of the suction type using anthracite pea coal and the gas engine, a three-cylinder vertical Fairbanks-Morse engine rated at 150 h.-p. and operated at 250 r.p.m. The fuel used during the test cost $6 per ton, making the minimum cost $0.00299 brake horse-power per hour.

The Central Boiler Plant of the Pullman Car Shops.

A 3,200-h.-p. central station boiler plant has recently been completed and placed in operation at the passenger car shops of the Pullman Co., at Pullman, Ill. These shops cover an area of 75 acres that is quite closely built up with wood and metal-working, paint, finishing and repair shops. The machinery in these shops varies from small machines in the wood-working shops to trip hammers and other heavy equipment in the metal-working shops. Practically all this machinery equipment is driven by steam engines, that were formerly supplied with power by a number of isolated boiler plants built in various parts of the works as new shops and equipment had been added. The new boiler plant replaces 20 old boilers of various types and capacities, and furnishes steam for power, lighting and heating in all of the buildings at the passenger car shops.

The building of the new boiler plant is near the center of the 75 acres covered by the shops. It has brick side walls on concrete footings, concrete floors and a reinforced-concrete roof carried by a structural-steel frame supported by the side walls and by two longitudinal rows of columns on each side of the center line of the building. The building is 80 x 131 ft. in plan, and 80 ft. high from the top of the concrete footings to the highest point of the roof. The frame of the building is divided in 3 longitudinal bays, one 23 ft. wide between the two rows of roof columns, with a bay 26 ft. wide on one side and one 31 ft. wide on the other side of this central bay. The interior of the building is one large room, with a clear height of 33.5 ft. and a 12-ft. basement having a concrete floor extending under the entire building. Over the central bay of the building the roof trusses are carried up to form a monitor roof, 33 ft. wide and with an extreme height of 22 ft. 9 in. above the ceiling of the main room of the building.

The present boiler equipment of the plant consists of a battery of eight 400-h.-p. Stirling water-tube boilers, placed in a single row in the 26-ft. bay on one side of the building. The other side bay of the building is practically all unoccupied and provides room for the addition of a sufficient number of boilers to double the present capacity of the plant. Over the central bay is erected a continuous steel coal bunker, which extends the length of the building and has a storage capacity of 1,000 tons of coal. Six of the eight boiler furnaces are equipped with Green automatic chain stokers and are regularly fired with coal from the overhead storage bunkers. The furnaces of the other two boilers have straight fixed grates, with ½ in. air-space openings and are regularly fired with shavings and waste lumber from the wood-working shops.

The coal and ashes are all handled entirely by automatic conveying apparatus, built by the Link-Belt Machinery Co., of Chicago. Coal is delivered to the plant on a railroad switch track along one side of the building. A concrete lined hopper built under this track is equipped with a belt conveyor leading to a receiving hopper from which the coal handling apparatus in the building is supplied, so coal can be unloaded from 4 cars at the same time. It is also possible to unload coal from a single car directly into the receiving hopper when the belt conveyor in the track hopper is idle. An automatic reciprocating feeding device at the bottom of the receiving hopper supplies a coal-breaker in which the coal is crushed to 1 in. and smaller. This breaker is in a concrete-lined pit in one corner of the basement of the building. A 20-in. corrugated apron belt carrier leads from the breaker up to one end of the central bay of the basement, where it discharges into the main portion of the coal conveying and distributing equipment. This equipment consists of an endless Link-Belt overlapping pivoted bucket carrier, which extends horizontally the full length of the central bay of the basement, up at one end of the building to the top of the monitor roof, then horizontally along over the coal bunkers back to the other end of the building and down to the basement again.

The buckets in this carrier are attached to extensions of chain links projecting some distance back of the articulating points of the chain and move on a different radius from the chain proper in passing corner wheels. This arrangement causes the buckets to separate enough to permit them to reverse their positions in relation to each other without interference between the overlapping edges. The buckets assume and maintain their proper positions by gravity under all conditions, overlapping on horizontal runs so as to form a practically continuous trough into which the coal is easily fed from the apron-belt carrier from the breaker, without spilling. A traveling tripping device, provided on rails under the horizontal run of the bucket carrier over the coal bunkers, permits coal to be dumped automatically into the bunkers at any point in the run. The coal handling equipment and crusher has a capacity of handling 40 tons of coal an hour between the breaker and the bunkers.

The coal bunkers have 16 hopper bottoms in two longitudinal rows of 8 each, one hopper for each of the 6 boilers which are fired with coal, that have been installed, one for each of the proposed future boilers, two for shavings and one for ash storage. The bottom of each hopper is controlled by an under-cut gate operated from the floor in front of the boilers. A 16-in. steel chute leads from each hopper to the supply hopper of the furnace stoker to which it supplies coal. The stokers are all driven from a line-shaft which extends the length of the boiler settings. Two 6-h.-p. slide-valve engines are provided to drive this line shaft, one at each end of the boiler settings, either one of which is capable of operating the six stokers.

The general arrangement of the chain grates of the mechanical stokers is shown in the accompanying cross-section of the boiler-house building from which it may be seen that a concrete floor with its surface sloping toward the front end of the grates is built under the latter back to about the end of the fire zone in the furnace. Any partly burned coal that falls through the grate is caught on this floor and discharged into steel hoppers in front of the stokers in the basement. The ashes pass from the end of the traveling grate down through an opening in the floor of the boiler setting into steel ash hoppers in a 10-ft. 9-in. by 9-ft. 10-in. room directly under the grates. The coal hoppers under the front end of the grates are in front of these ash-hopper rooms, each of the latter being tightly closed by two sheet-steel doors to prevent cold air entering at the rear of the furnaces.

The steel ash and coal hoppers under each boiler furnace are suspended on wheels from an overhead track consisting of two steel beams, which extend at right angles to the horizontal run of the pivoted-bucket coal handling carrier in the basement, and from the rear end of the ash-hopper room to 12 ft. beyond that carrier. The ash-hopper has a capacity of about 225 cu. ft., and the coal hopper of 75 cu. ft. The coal and ashes from these hoppers are discharged into the pivoted bucket carrier and are elevated by the latter to the monitor of the roof, where the coal is dumped into the bunkers again and the ashes are dumped into chutes leading out of the building.

The storage capacity of the ash and coal hoppers is such that they have to be emptied only once every 24 hr. The hoppers of all of the furnaces are generally emptied at the same time. The coal hoppers are all first rolled on the track out over the coal carrier and dumped into the carrier through under-cut gates in their bottoms. The empty hoppers are then pushed beyond the carrier and after the coal has all been elevated to the bunkers, the ash hoppers are run out and their contents discharged into the carrier. The bottoms of these ash hoppers have the same width as the guard on each side of the buckets of the carrier, and are closed by two flat hinged gates which drop down and rest against the carrier guards. These hoppers are roughly 8 ft. 11 in. long, 6 ft. wide and 6.5 ft. high, over all, and weigh approximately 7 tons when full. They are so arranged, however, that two men easily pull them out of the rooms in which they normally set and over the carrier, when they are fully loaded.

The ashes are discharged from the buckets of the carrier by an automatic tripping device in one end of the monitor that is entirely distinct from the tripping device used when coal is being discharged into the bunkers. The ashes are discharged into a small steel hopper directly beneath the end of the horizontal run of the carrier in the monitor. Two 16-in. steel chutes lead from this hopper down to cars on a track along one end of the building. These chutes are arranged with a gate so ashes may be discharged through either of them. In case the car is not on the track the ashes can be discharged into one of the steel bunkers, which is separated from the coal and shaving bunkers by a double steel partition, where it can be stored until a car is available.

The shaving and scrap lumber burned in the two boiler furnaces equipped with ordinary straight grates are supplied from three separate sources. The planers and similar wood-working machines regularly produce large quantities of shavings. All of the new scrap lumber that is free from nails and metal is ground into shavings in a specially constructed grinding machine. The remainder of the scrap lumber is fired in the furnace as it is produced. The shavings are blown by fans from the machines producing them through galvanized iron ducts leading over the shop buildings to 4 large sheet steel separators on the roof of the boiler house. Seven main ducts lead to these separators, the extreme length of the ducts being 800 ft.

Steel chutes lead from the separators directly to the furnaces of the boilers and to a storage vault built along one side of the overhead coal bunkers. The quantity of shavings produced is generally between 55,000 and 60,000 cu. ft. of finely packed shavings every 24 hrs., but it varies widely, although it is practically always sufficient to fire one boiler during the day. When the supply of shavings exceeds the capacity of the two boiler furnaces the excess is turned into the storage vault. During the night the shops are generally closed, and then the shavings stored in the vault are drawn down on the floor in front of the furnaces through large straight steel chutes and fired by hand. It was found impracticable to attempt to draw the shavings from this vault and discharge them directly into the furnaces, owing to the manner in which they would arch in the vault. The furnaces of each of the two wood-fired boilers have two 4x8-ft. old style brick arches. The arrangement of chutes leading from the separators to these furnaces and to the storage vault is such that any separator will discharge into either side of either furnace, or into the vault, the gates controlling the flow being operated with chains from the firing floor. Most of the shavings handling apparatus was built and installed by the Allington & Curtis Co.

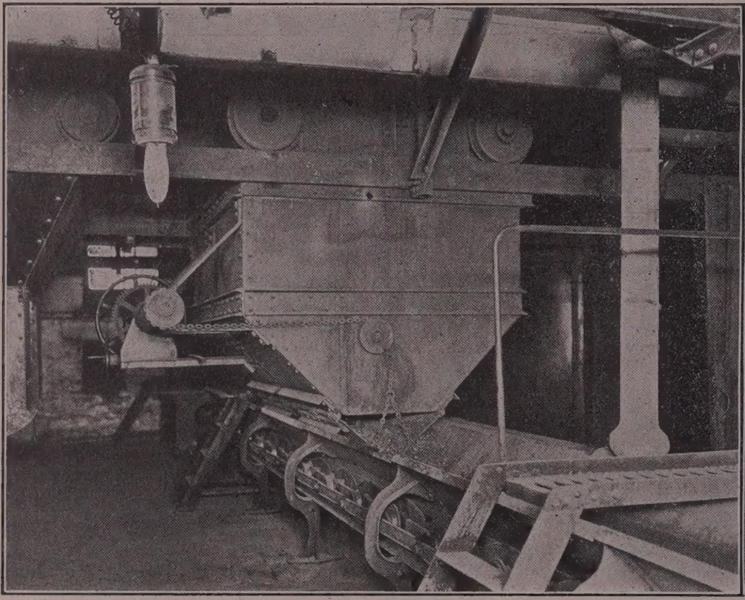
The scrap lumber containing metal is hauled into the building from the adjacent shops in carts and dumped on the firing floor in front of the boilers. Such lumber of this class that is obtained from the distant shops is loaded in standard-gauge cars, which are hauled into the plant on a track laid in the floor of the boiler room. A hoist driven by a small steam engine is used to pull these cars up an incline leading to the floor of the boiler room, as that floor is above the ground level, and along the track in that room.

The boilers are served by a 250-ft. circular brick stack with an internal radius of 12 ft. The breechings of the boiler furnaces are connected with this stack by a brick smoke duct. The construction of the Stirling boilers is such that the breechings for the boiler furnaces could be built entirely below the floor level of the boiler room. The downtakes and breechings are built of fire brick, the breeching being 7x8 ft. in the clear in cross-section at the end farthest from the stack and 12x12-ft. at the end nearest to the latter. A draft equivalent to 1¾ in. of water is produced at the base of the stack, while the draft in the breechings does not fall below 1½ in. of water at any point.

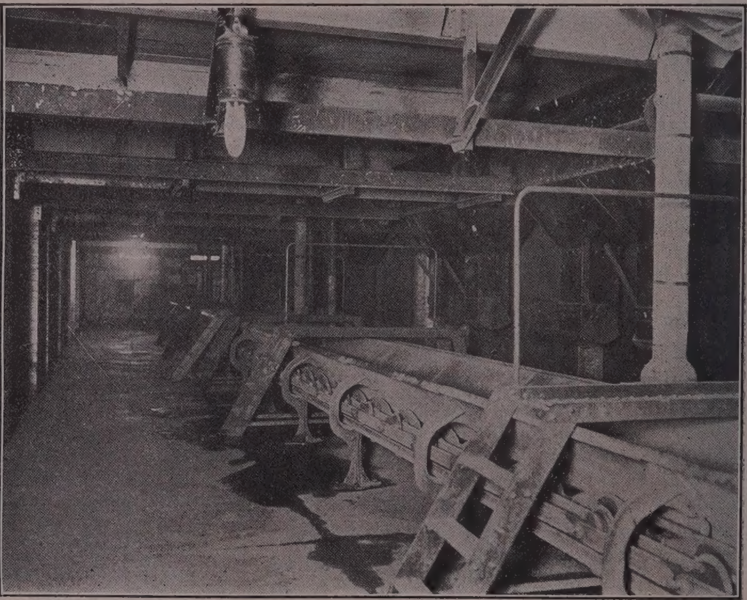
The water supply for the boiler plant may be drawn from municipal water works mains which are supplied from Lake Michigan, or from the water system of the shops, which is supplied from the Calumet River. All of the feed water for the boilers is heated in a Cochrane feed water heater, which has a capacity of 4,000 h.-p. The boilers are regularly supplied with feed water from this heater by an automatically-operated, tandem-compound 16x25x12x20-in. pump made by the American Steam Pump Co. A Worthington central duplex pump is also available to pump feed water in case of an emergency. Two distinct feed-water mains are installed to supply the boilers; a 7-in. main is laid the length of the building in the basement and directly in front of the row of boilers; a 6-in. main is also provided 12 ft. above the first floor, back of the row of boilers, extending the length of the building. The 6-in. main is also connected with the water-works distribution system of the shops so in case the feed-water connections with the heater fail entirely cold water may be supplied to the boilers. The boilers are ordinarily supplied from the 7-in. main in the basement through a 2½-in. connection with the rear top drum of each boiler in the usual manner. This 2½-in. pipe also connects with the 6-in. feed-water main back of the boilers. Two valves on each of these 2½-in. connections permit water to be supplied from either or both feed-water mains. An Empire or Trident hot water meter is placed on a by-pass on the feed-water connection for each boiler. These meters are generally operated 4 or 5 hrs. a day to determine the amount of water each boiler is consuming. The feed pipe system is connected to a testing set capable of and arranged to test one or all of the boilers, and a test can be started in a very short space of time and with a minimum amount of labor.

The feed-water supply to each boiler is controlled by a Murray automatic valve. This valve is actuated by a float in the water column of the boiler, and is normally closed, being held on its seat by a spring. When the water level in the boilers falls below a pre-determined point steam is admitted under the control valve and water supplied to the boiler. The steam supply for the feed-water pump is also automatically controlled, so the speed of the pump is regulated according to the amount of water being furnished to the boilers. A relief valve is also provided in both feed-water mains to prevent damage from excess pressure.

A 20-in. steam header extends the length of the row of boilers on iron brackets supported from



Ash Hopper Pulled Out Over Horizontal Flight of Carrier.

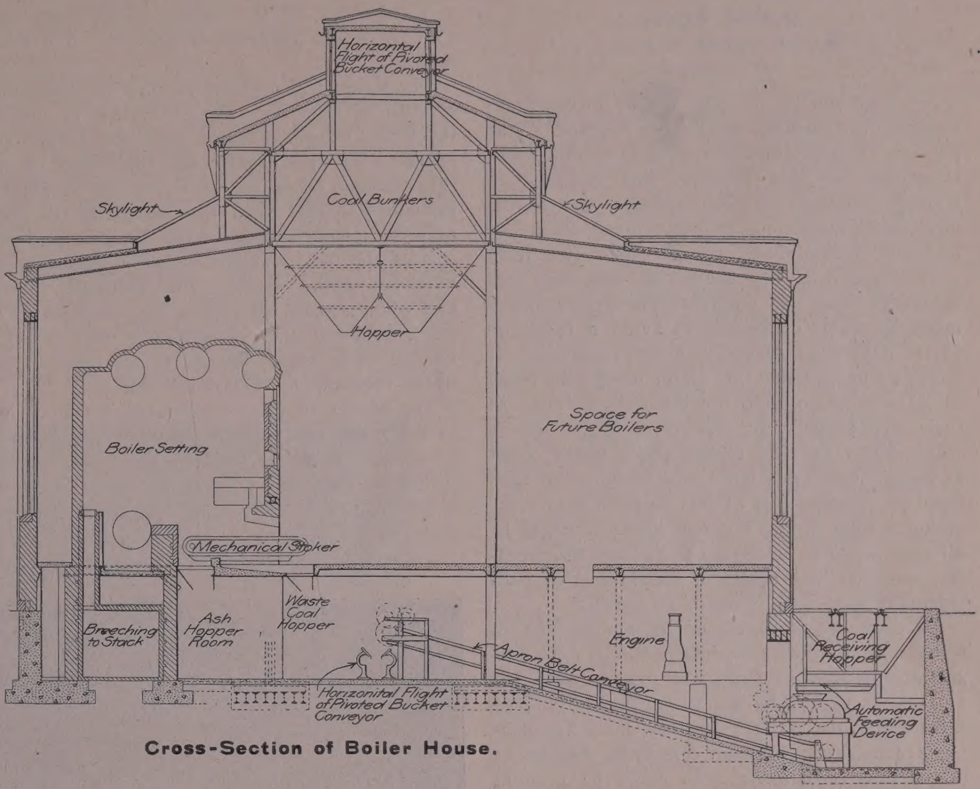


Horizontal Flight of Carrier in Basement of Building.

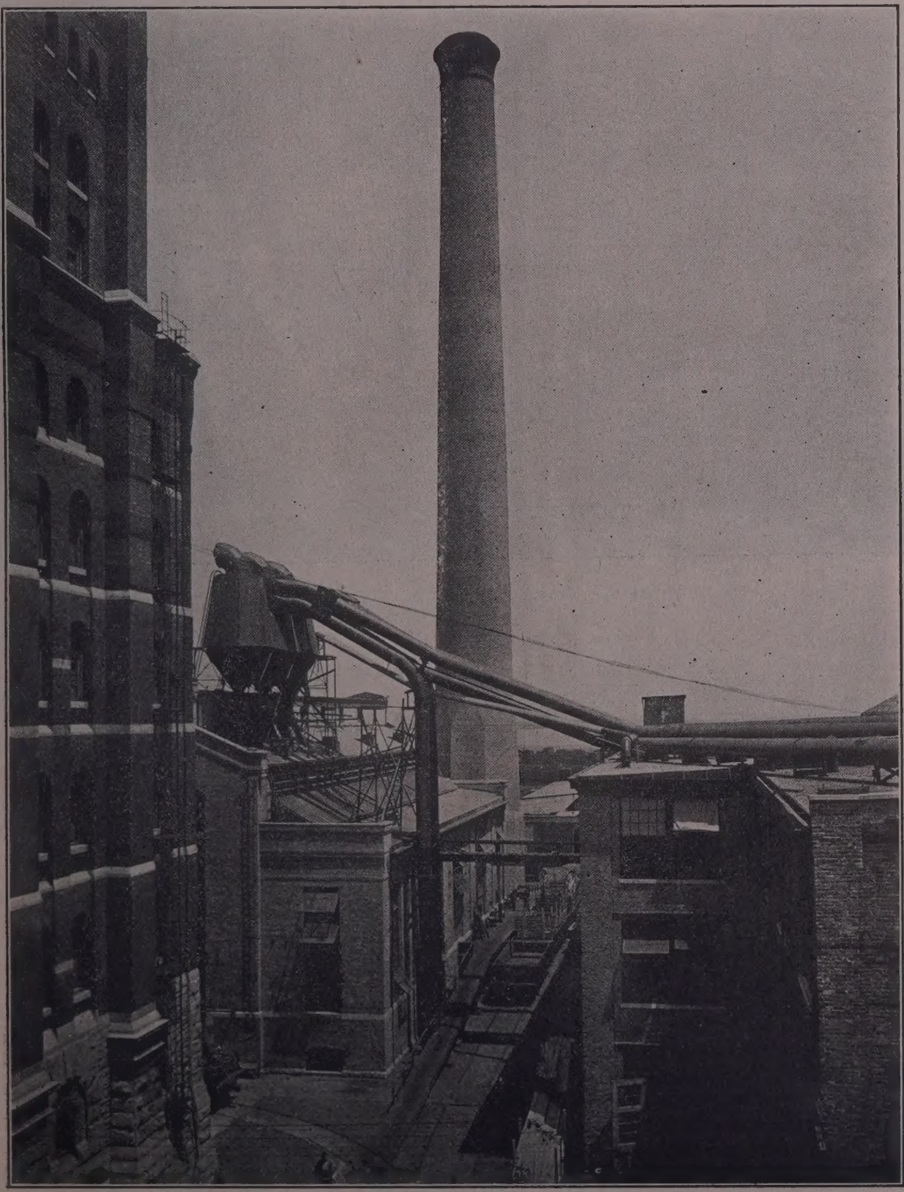
the wall of the building back of the boiler settings. Each boiler has an 8-in. connection to this header, which is at the level of the rear top drums of the boilers. An 8-in. Pratt & Cady gate valve and an 8-in. Crane automatic stop and check valve is provided on each of these connections. The stop and check valves automatically prevent back pressure reaching the boilers, but they are also capable of hand operation. Each boiler is provided with two 4½-in. Ashton blow-off valves.

An iron slat walk is erected along over the back end of the boiler settings between the rear drums of the boilers and the 20-in. steam header. The boilers are set in pairs with an iron stairway at each end of the building leading from the boiler room floor to the walk over the boiler settings. This walk is so located that all of the valves on the feed-water and steam connections are readily reached from it.

The various engine plants supplied from the boiler plant are furnished with steam by a number of branches from the 20-in. header. These branch distribution mains are all carried overhead and have a maximum length of 1,000 ft. All of the steam and feed-water connections within the building are insulated with 85 per cent. Keasbey & Mattison magnesium pipe covering. The distribution mains outside of the building are all covered by double thicknesses of this material. Even with the extreme lengths of outside distribution mains a comparatively small drop of pressure and a small amount of condensation is experienced in the operation of the plant. An improved vacuum pump made by the American Steam Pump Co., is in duplicate in the basement of the plant and handles return condensation water from all parts of the plant.



Cross-Section of Boiler House.



Shavings Separators on the Roof of the Power House.

Particular attention has been devoted to the arrangement of the windows and skylights of the building with the result that the interior is unusually well lighted. A comparatively large amount of window space is provided in both sides of the building so that the passageways between the rear of the boiler settings and the side walls of the building have sufficient light. The end walls of the central bay of the building are largely window space. Two wide skylights are provided in the roof, one on each side of the monitor. These skylights extend the length of the building and are placed in the angles between the main portion of the roof and the sides of the monitor. Their arrangement is such that the light is thrown from the skylight on one side down between the coal bunkers and the boiler settings on that side of the central bay to the front of the boiler settings on the other side and on the floor in front of these settings. At the same time the tops of the boiler settings on that side are unusually well lighted, as may be seen from one of the accompanying reproductions of a photograph taken on top of the boiler settings. The erection of settings for the proposed additional boilers will in no way interfere with the lighting arrangement of the plant.

The boiler plant was designed by Mr. C. Frank Jobson, architect for the Pullman Co. Messrs. Robert W. Hunt & Co. were consulting engineers to the Pullman Co. during the design and construction of the plant. The steel work in the building was detailed and erected by the Kenwood Bridge Co., of Chicago, and the entire contract for building was under the R. & S. Sollitt Co., of Chicago.

To Cause Paint to Adhere Firmly to galvanized iron, the Government has recently adopted specifications compelling the use of vinegar for washing the surface preparatory to painting. This is said to corrode or roughen the surface, thus giving the paint better opportunity to adhere.

Guarding Against Electrolysis of Underground Pipes.

By Mr. Putnam A. Bates.

Although during the past ten or fifteen years a number of damage suits have resulted in the payment of large sums of money to certain water companies of this country and England to liquidate damages to their systems, due to the mechanical weakening and consequent failure of hydrants, water mains, service pipes, etc., from electrolysis, it is noticeably true that only occasionally does one find that any precaution is taken by water companies to avoid a repetition of the experience of others in this direction. It might be argued that the water companies being in no way responsible for the damage done to their own property by electrolysis ought not to worry about any bad effects which might result at some future time, but a small amount of time spent in consideration of this problem before the piping system is laid out and installed might be all that would be necessary to prevent this needless damage, and result in the saving of considerable money and much bitter feeling.

An examination of the conditions existing in water systems which have been installed for a considerable length of time, and which were put in without regard to the possibility of damage from this cause, is likely to show most astonishing results, and if water companies located in the vicinity of electric lines could be brought to see the wisdom of making periodic tests for the presence of stray electric currents and act accordingly, much damage to the water pipes could undoubtedly be prevented by taking the necessary steps to prevent the flow of these stray currents before a sufficient time for the destruction of the pipes had elapsed.

The chance of danger varies so with local and climatic conditions that it is almost impossible to lay down rules which would be proper for all installations. It is likewise true that conditions indicated from tests made at one season of the year do not necessarily hold good for others. Therefore, to get a comprehensive idea of the situation in any one case, it is necessary to study the problem from the standpoint of the particular installation in question, and to conduct tests under the extreme as well as the average conditions.

Electrolytic action will take place wherever a current of electricity leaves a conductor which is capable of being oxidized (such as cast-iron, wrought-iron or lead water pipes) and passes into some other conducting medium in the presence of more or less dampness, except in cases where the current passes directly from one metal conductor to another by direct metallic contact.

Thus it will be found that wherever a current of electricity leaves a line of water pipe and passes into the surrounding earth or water, either to follow some other path or to return to the pipe after passing some obstacle offering electrical resistance, such as an imperfect joint, more or less electrolytic action will be taking place, depending upon the volume of current leaving the pipe. This electrolytic action will result in corrosion and more or less rapid eating away of the pipe at the point where the current is leaving, which will in time cause the pipe to fail.

A point which the railroad companies seem to loose sight of is the fact that their own property is being damaged as well as that of the water companies having pipes in the ground. Wherever the current leaves the rails, to pass through the earth into a piping system, due to a defective rail bond in the return circuit, electrolytic action will take place, and slowly but surely the rails at such places will be eaten away and will have to be replaced at considerable expense. A thorough bonding of the rails in the first place and a careful test of the return circuit from time to time would reduce this difficulty to a minimum.

The writer had occasion recently to make some exhaustive tests on a water system of one of the larger suburban towns lying just beyond the outskirts of New York City, the object of the investigation being to determine the conditions prevailing in that town with regard to the presence of leakage currents from the grounded circuit of the local traction company, operating an overhead trolley system with grounded return, and whether such currents if they were found to exist, followed such a path and were of such volume as to cause damage to the pipes of the water company by electrolytic action.

The results of these tests made by the writer to determine the presence and direction of flow of leakage currents, between the tracks of the trolley company and the gas mains, water mains, hydrants and service pipes, showed the conditions shown in Table I:

The actual difference of potentials at the time these tests were made between the minimum of 0.3 volt (which was the smallest amount which could be read with certainty on the instrument) and a maximum of 11 volts depending upon the location of the point where readings were taken, amount of current taken by, and the position of the various trolley cars at the time when the tests were made.

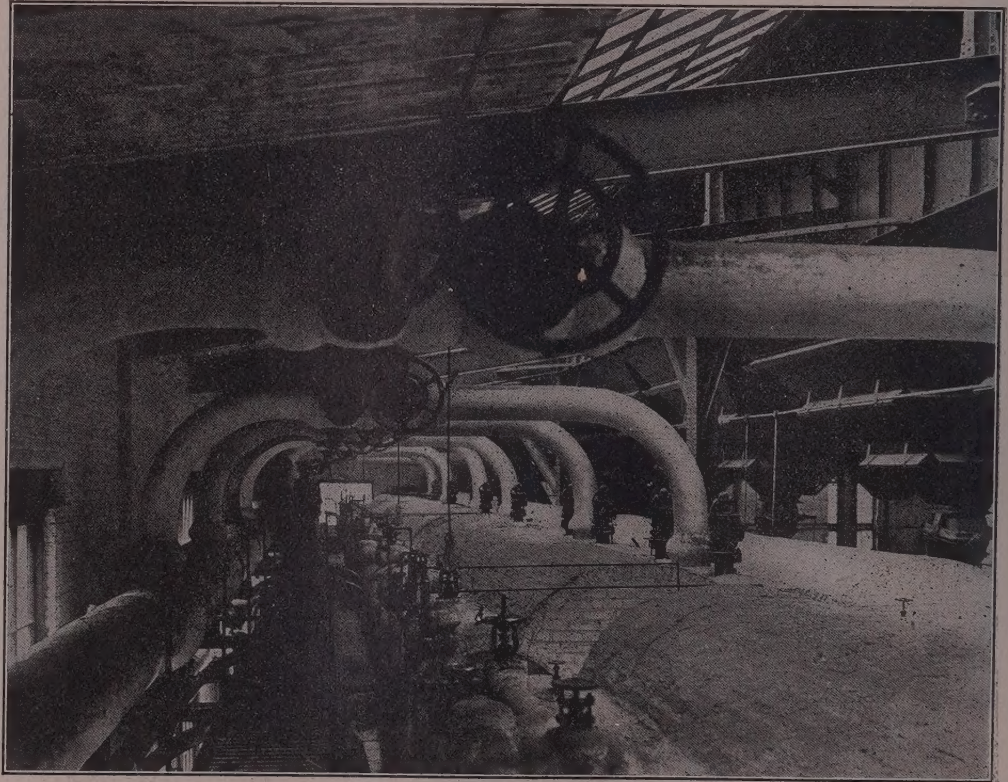
These results indicate that a current of electricity of varying amount (depending upon the physical condition of the ground and the amount of current being used by the trolley cars at the moment) was leaving the trolley rails and finding its way into and along the pipes of the water company, traversing that path until it could find a point of low resistance at which to leave the water system, and go to earth to return again to the source from which it emanated.

Having determined these points, it still remained to ascertain as nearly as possible the volume of these leakage currents, as it is this alone which fixes the amount of damage which such stray currents are capable of causing. This was a much more difficult point to settle owing to the various electrical and physical conditions beyond our control.

TABLE I.
AMOUNT OF LEAKAGE CURRENT.

	Location.	*Volts*
1.	Between gas main and trolley track....	0 to 0.6
2.	Between water pipe for hydrant No. 36 and trolley track....................	1.5 to 6.0
3.	Between hydrant No. 31 and trolley track	1.6
4.	Between hydrant No. 31 and gas lamp post (lamp post positive)............	0.9 to 1
5.	Between hydrant No. 31 and sewer manhole (hydrant negative)..............	1.1
6.	Between hydrant No. 24 and trolley rail.	3 to 4
7.	Between hydrant No. 24 and gas lamp post (lamp post positive)............	0.6
8.	Between hydrant No. 19 and trolley rail.	3.5
9.	Between hydrant No. 10 and trolley rail.	4 to 11
10.	Between hydrant No. 6 and the end of trolley rail	4.5
11.	Between hydrant No. 3 and sewer pipe, where latter enters salt water bay inlet nearby	1.0
12.	Between hydrant No. 28 and trolley rails.	2.5
13.	Between trolley rails and river running into above mentioned bay inlet........	2.5
14.	Between hydrant No. 30 and trolley rails.	2.5 to 4

The voltmeter used for these tests was a Weston 0-15-volt instrument, having a resistance of 1,357 ohms. The tests were made between the hours of 10 a. m. and 6 p. m. under ordinary conditions as found daily.



The Top of the Boiler Settings, Pullman Boiler Plant.

In reading over articles on electrolysis, one very often sees statements made that if there is a difference of potential between any point on a pipe line and the surrounding earth, that point will be subject to electrolytic action, and the amount of the electrolytic action will be indicated by the difference of potential between that point and the surrounding earth. This is a fallacy and very often leads to erroneous results; for example, a test was made on a piece of L shape water pipe which supplied several houses located near the water front. The difference of potential between the corner of the L and the body of water was found to be 12 volts; the difference of potential between the body of water and a point on the extreme right of the L was found to be 3 volts. This would seem to indicate that a large amount of current was flowing from the corner of the L to the body of water and thence back to the generator. As a matter of fact, this particular point was free from electrolytic action, and the other point mentioned above having a difference of potential of 3 volts had considerable action taking place. The explanation of the above condition is found in the fact that 9 volts were dropped in the horizontal portion of the L. The corner of the L was on a hill composed of dry, sandy loam and the extreme right of the L was on lower ground which was constantly damp. Thus it is seen that a high difference of potential between any point on a pipe line and the surrounding earth or water, does not necessarily mean that much electrolytic action is taking place at that point. Reports and statements on electrolysis, as a general rule, refer only to difference of potential and make no mention of the current flowing, in spite of the fact that the work of electro-chemists all over the world has long ago established the fact that it is the volume of current flowing, and not the difference of potential between the electrodes, which determines the amount of metal which will be eaten away from the anode or conductor, from which the current passes into the surrounding electrolyte. While the difference of potential is a fair indication of electrolytic action it must not be blindly relied on in determining the extent of electrolytic action at any point.

Fronts and Automatic Stokers of a Pair of Boilers, Pullman Boiler Plant.

In this particular test, it was found possible to determine the amount of current flowing in a loop of piping running from hydrant No. 41 to hydrant No. 2 and also on a loop feeding hydrants Nos. 40 and 9. In each of these loops a current was found of such volume as would be capable of causing rapid deterioration of the pipe if physical conditions were such as to cause that current to leave the pipe in a restricted area. If, however, as may be the case, this current should leave the pipe throughout a considerable area, it is probable that the damage done by electrolytic action would not be sufficient materially to affect the life of the pipe over that area.

On one occasion, between 11.30 a. m. and noon, when the load on the trolley system was at its minimum, a test was made to determine as nearly as possible the total amount of current entering the water system due to the leakage from the rails of the trolley road. With the exception of the time when the road was entirely shut down, it was found that a current of very considerable magnitude was leaking from the trolley rails into the water mains. The current was of such volume, even at that time of the day, as to be capable of doing very considerable damage, and during the busy hours of morning and evening the current would naturally be even greater. Of course, the mere presence of the current in a piece of pipe does not always mean that that particular piece of pipe must necessarily be subject to electrolytic deterioration. A great many joints in a pipe line might be so good electrically as to prevent the escape of enough current to cause the action. The current might manifest itself at one point, and no electrolysis might be taking place within several hundred feet of this point. If pipe lines could be laid so that the stray current would not leave them, except by a metallic connection with the negative side of the dynamo at the power house, electrolytic action could not occur. Unfortunately, this is impracticable owing to the nature of the soil and the method of the pipe-line construction.

The flow of current in the above test was found to be continuous all during the time of test, although it showed the characteristic fluctuations of the trolley current caused by the variation in the power consumed by the trolley cars in operation at the moment. This current, though very small in volume, caused very much trouble, as it was compelled to leave the pipe in a restricted area. This condition might arise at any time, due to some portions of the pipe surface offering an easier exit for the current than others, or due to a leak in the pipe forming a small stream which might work its way through the soil, making a low resistance path for the electric current through the earth and causing the current to be concentrated at this point. This same condition might arise from sub-surface streams crossing the pipe line, or at points where the pipe passes in a short distance, from comparatively dry earth into damp or wet earth, such as marsh lands. Again, this condition might be brought about by a very bad joint in the pipe line, over which the current was flowing, offering more resistance to the passage of the current than the surrounding soil, which is a very common occurrence, in which case the current would leave the pipe at the joint to re-enter it further on.

One of the most interesting points brought out by the test referred to and the careful investigation which followed it was, that wrought-iron and lead pipes forming the service connection to buildings taking water from city mains are more susceptible to electrolytic action than the cast-iron water mains themselves, and having so little body are rendered useless in a much shorter time than the large mains would be by the same current.

There is a physical reason for the lesser susceptibility of the cast-iron pipe to this electrolytic action, and it is to be found in the method of its manufacture and finish.

In casting these pipes the molten metal fuses the sand immediately surrounding them, and upon cooling, this fused sand forms a silicious or glassy surface over the pipe. While this coat is extremely thin and is not uniform in its nature, it offers an appreciable resistance to the passage of electric current either into or out of the pipe, and this partial insulation of the pipe surface is often added to by a coating of asphaltic paint applied to the outer surface of the pipe. Wrought-iron and lead service pipes, on the other hand, have no such protecting coating, and as they are usually secured to the street mains by a screw joint or wiped joint, the electrical connection between the two pipes is excellent, and if one or more of these service pipes is located near some point where the current tends to leave the mains, it will be found that the current will use them as an exit and they will therefore be rendered unserviceable by electrolytic corrosion due to this current.

As a result of the tests and investigations herein referred to, it may be stated that the following facts were disclosed with respect to this particular system: (1). That a leakage of electric current from the rails of the trolley company does exist. (2). That the leakage current enters the pipes of the water company, and after passing along these as conductors, leaves the pipes and passes into the surrounding earth, where low resistance is offered. (3). That this current is of sufficient volume to cause very appreciable damage to the pipes. (4). That this damage will be more apparent in the small service pipes than in the mains, partly because the amount of metal in them is so much less and partly because they form an easier exit for the current, on account of their physical structure.

A conclusion which the writer has found to be frequently demonstrated and which is apt to be overlooked is, that a water pipe system may seem to be practically everywhere positive to the trolley rails, and yet be in a dangerous condition. The reason for this is simple enough if one gives it a little thought, yet tests have been reported as showing a safe condition when the current was actually leaving the pipe at a point which could not well be tested from the surface, and would re-enter further on, making the next hydrant or exposed joint indicate a positive relation to the trolley system. Much time and money have also been spent for tests which have resulted in reports being rendered, that a safe condition existed, when serious damage was actually taking place, owing to the fact that the tests showed a leakage current of an extremely low potential, no effort being made to determine its volume.

In outlining the above test, I have dwelled considerably on the cause and effect of stray current from trolley systems, and before concluding wish to say a few words regarding the various methods of preventing and guarding against this destructive foe.

After a grounded return trolley system has once been installed in the neighborhood of a piping system, there is nothing that a water company can do to absolutely protect their pipes from electrolytic action. There are many ways, however, in which they can reduce the trouble to a minimum. As an example, it was found in the above test that a large number of lead service pipes were so badly corroded that they became absolutely useless. This was brought about by the fact that the current in leaving the piping system at certain points, left by way of these lead pipes and passed through the earth for a distance of about 50 ft., and then entered another main. If a jumper of sufficient cross section had been connected between these two mains, which were about 50 ft. apart, the current would not have left by way of the lead pipes and they could have been saved. Several remedies can be applied to parts of an affected piping system, which will in most cases result in saving such affected districts.

It rests entirely with the trolley companies to decide whether their systems shall or shall not cause electrolysis of underground pipes. If they so choose, they can entirely prevent the nuisance. They have but two questions to consider, viz: shall we put in an expensive return system and be sure no pipes are being damaged, or shall we save considerably on our first cost by using a track return and run the chances of paying damages to the water company for destroying their pipes? Unfortunately, they usually choose the latter.

When the return circuit is grounded, it is impossible to entirely prevent the escape of current from the return system, but the amount of leakage current can be greatly reduced by thoroughly bonding or welding the joints in the track. In time, however, due to wear and atmospheric conditions, some of these joints might become defective and leakage result. A very good way to detect defective bonds after a system is in operation is, to make a trip over the road after a slight snow fall and take a look at the various bonds. Defective bonds will manifest themselves by melting the snow about them, due to the heat caused by the high resistance of the joint. This, however, will only point out bonds which are in very bad condition.

If it were possible to maintain a balanced condition, a three-wire system might be used in which the ground could act as a neutral and the two trolley wires as the outsides. This, however, is rarely done, as it is next to impossible to keep the two sides of the system balanced and any unbalancing would cause current to flow through the earth and the surrounding pipe lines. A good feature of the three-wire system, however, is the fact that the stray current which would flow through the ground would not always flow in the same direction. When one side of the system became unbalanced, the ground, acting as the neutral, would carry the current in one direction, and when the other side of the system became unbalanced the current in the ground would flow in the opposite direction so that while any water pipes which might pick up the current would be eaten away at one time, they would have metal deposited on them when the current flowed in the opposite direction.

Another method which might be used is to apply an extra generator at the power house, the negative side of which is connected with the piping system and the positive side to the feeder system. If this generator is kept at a slightly higher potential than the rest of the system, all underground pipes to which it is connected will become electro-negative and electrolysis will be prevented to some extent. This system, however, has many disadvantages and is rarely, if ever, employed to mitigate the nuisance.

If the danger zone has been definitely located on any piping system, a large conductor can be run from the negative side of the generator and be connected to all the pipes of the underground system in the affected territory. This might happen to be a good many miles from the power station and for that reason becomes impracticable in many instances.

There are a few other methods which slightly improve conditions, but there is only one satisfactory way out of the difficulty, and that is to install a complete metallic circuit for the traction system. This is usually accomplished by employing what is known as the double trolley system in which arrangement the current passes from one trolley to the motor, through the motor, and out through the other trolley to the second trolley wire and thence back to the negative side of the generator, both wires being insulated from the ground. This system has been employed in several of the Western cities.

When the open conduit system is used, as is the case in our larger cities, the circuit is completed through two conductors lying side by side in the conduit and both being insulated from the conduit. With these two arrangements, there is little inducement for a current to be diverted from the conductors and to stray off on iron pipes or underground metallic structures, taking some other course back to the negative side of the dynamo.

While these two methods of overcoming electrolytic action add somewhat to the first cost of the electrical equipment of a railroad system, the results obtained are always well worth the additional outlay.

SURVEYS AND BORINGS are now in progress for the location of a great bridge across the St. Lawrence River at Montreal, Canada, which is to be built by the Montreal Bridge & Terminal Co., of London and Montreal, and with the terminal building to be erected in connection with it, involves an estimated expenditure of $12,000,000. The structure will be of ample proportions to provide for several railroad and trolley tracks, highways and sidewalks and will have a 1,500-ft. cantilever span at a clear height of 150 ft. over the channel, besides shorter spans and about 1½ miles of steel approaches. As the river at the point where the bridge is to be located is 30 ft. deep, with a very swift current, and is yearly obstructed by enormous fields of ice, the design of the substructure and superstructure will be made with no small difficulty. The substructure will involve at least two piers that will have to be built in some type of pneumatic caissons. Mr. F. Stuart Williamson, of New York, and Mr. F. W. Fox, of London, are the associated engineers for the company that is forwarding the project.

Sewerage Extensions in Glasgow.

The third and final section of the drainage works for Glasgow has now progressed far enough that it is expected to be completed within three years. The main drainage scheme of Glasgow, which was undertaken 14 years ago, is, next to that of London, the largest in the world for the treatment of sewage. The territory included in the scheme stretches along both banks of the River Clyde for about 15 miles, and embraces 39 square miles, which may be increased by the inclusion of areas controlled by other local authorities. This drainage area is divided in three distinct sections, each with separate works for the treatment of its sewage. The ultimate volume of sewage and the portion of storm water to be treated is estimated at about 300,000,000 gals. per day.

The first section of the drainage area comprises 11 square miles, one-half within the city and the remainder in Lanarkshire, with works for the treatment of the sewage at Dalmarnock, near the east end of Glasgow, to which the sewage is delivered by a main outfall. The second section comprises such of the municipal and adjacent areas of Glasgow on the north side of the river as are not included in the first section. The works for the treatment of the sewage from this section are about 7 miles below Glasgow on the bank of the river. The third section includes the entire municipal and adjacent area of Glasgow on the south bank of the river, for which five miles of sewers have already been completed.

The flow reaching the works of the first section amounts to approximately 19,200,000 gal. a day, and consists principally of industrial refuse, with suspended matter varying from 20 to 1,000 grains per gallon. The system of treatment of these works is chemical precipitation, with under-surface continuous flow. The effluent from the works is discharged into a tidal stream and is diluted 50 times. These works are said, in a description of the Glasgow drainage scheme in the engineering supplement of the London Times, to eliminate all suspended matter and to effect 30 per cent. of chemical purification, calculated on the basis of oxygen absorbed in four hours at 27° Cent. An original installation, including filters at these works, has been abandoned, as the filters are considered to have deteriorated the effluent instead of improving it.

The second secton of the drainage area delivers 250,000,000 gal. of combined discharge per day to the works built to serve it, the excessive storm water run-off being diverted into the river. One treatment works for this section has been completed for some time and a second is to be built. The outfall sewer of this section discharges into chemical precipitation tanks at the works that have been built, the sewage flow passing first through screens and a grit chamber. The chemicals are added in the grit chamber, from which the sewage is diverted to the precipitation tanks. These tanks are worked in series on the principle of under-surface continuous flow. The effluent from the tanks passes over a discharge gauge weir into the river, receiving a dilution of about 30; the sludge drops into underground channels from which it is pumped into storage tanks and finally delivered to a sludge steamer which conveys it out to sea.

The sewerage systems in sections one and two of the main drainage area already divert the sewage of the north side of the city from the river. As the completion of the system of sewers that has just been started in section three will permit the sewage from the south side of the city and the adjacent areas to be purified before it is discharged into river, the city will eventually be in a position and expects to provide for the purification of the entire Clyde basin.

The Chalmette Docks of the New Orleans Terminal Co.—II.

The work outside of the levee is being done by entirely different methods from those which have been followed on the work back of the levee. This part of the work includes the two river or wing walls and the return or slip walls through the levee. The upstream and downstream river walls are 520 and 575 ft. long respectively. The slip walls are about 345 ft. long each. They join the inshore work at their intersections with a line parallel to and 260 ft. from the front of the river walls, or about 75 ft. inshore from the center of the levee.

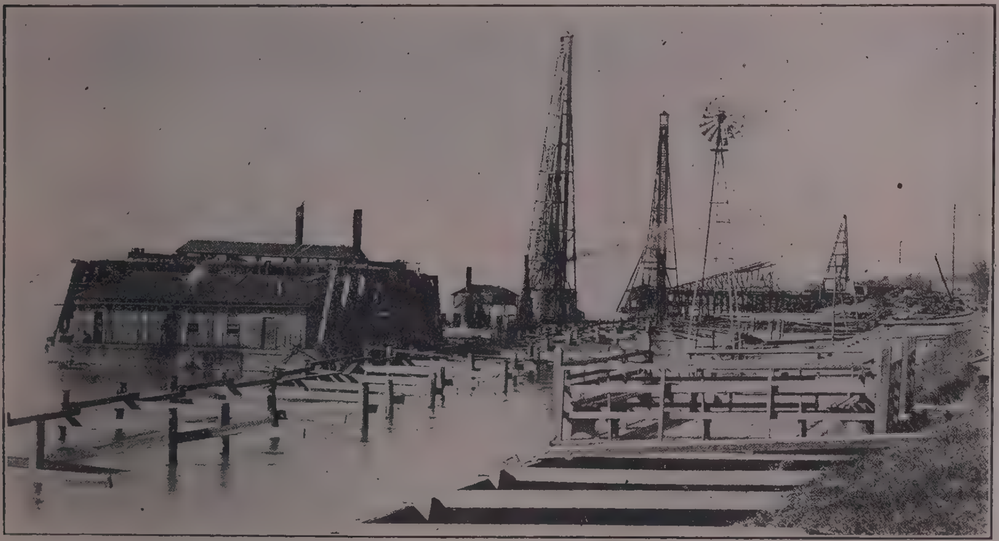
The low-water shore line is from 25 ft. to 100 ft. from the toe of the levee, but beyond that the bottom of the river drops away rapidly, so that the depth along the front of the river walls is from 20 to 35 ft. at low water. Since the inception of the work, however, the stage of the river has varied from 5 to 15 ft. above low water, so the maximum depth within the limits of the footings has varied from 40 to 50 ft.

The foundation piles for the river walls were cut off at the same elevation as those for the land sections, namely, at Elevation 15.74, or 2 ft. below low water, or 7 ft. below the lowest water since the work was started. Originally the idea was to do the river work in coffer dams, but The Foundation Co. regarded that method of construction as unusually hazardous, for this particular job, and decided to use a floating caisson or huge diving bell for sawing off the piles and for placing the caps and grillage timbers.

The piles are all driven by floating drivers mounted on scows. These drivers have fixed leads, 100 ft. long, with extension leads, 100 ft. long working within the fixed leads. The guides of the fixed leads are each made up of a 6x9-in. timber with a 3x8-in. side guide placed on each of its narrow sides so as to form a U-shaped section with square corners. The inner faces of the two guides are 41 in. apart. The extension leads are made up of two 8x10-in. timbers which slide in the U-shaped guides of the fixed leads, as shown in the accompanying cross-section. The faces of the extension leads are kept 20 in. apart by steel yoke separators placed every 10 ft. of their length. The drivers are each equipped with a No. 1 Vulcan steam hammer, which has a 5,000-lb. ram. The extension leads were suspended from a fall line passing over a sheave in the top of the fixed leads to drum of hoisting engine on the scow. The hammer and a follower timber were lashed together and suspended from a second fall line passing over a sheave on the top of the fixed leads to another drum on the hoisting engine.

Piles 50 to 75 ft. long were driven and were followed 5 to 15 ft. under water. When a pile could not be driven the full depth it was sawed off at Elevation 17.0 with a submerged circular saw mounted on a vertical shaft on a scow. The follower timber was provided with a guide casting on the lower end to keep it in the leads. The casting was cupped on the bottom and fitted over the head of the pile when in position, thereby holding it firmly between the leaders while being followed down. Where swift current was encountered a light wooden frame was nailed on the lower end of the pile before it was driven. This frame consisted of a piece on each side of the pile inside of the leads to hold the outer pieces parallel and against the sides of the leads. This frame slid down on the leads with the pile and landed the point of the latter in its exact position between the leads.

The surface of the bed of the river to a depth of 2 to 10 ft. is very soft silt. Below this silt is fairly good material, varying from clay to fine sand. With the use of the follower as arranged, as high as 75 piles a day have been driven, the average number driven in a day ranging from 30 to 40. A total of 5,000 piles had to be driven under water on the off-shore work.



Partial View of Plant in Operation on Underwater Work.

The general plans and the appearance above the water of the floating caisson used in cutting off and capping the piles and in placing the timber grillage may be seen in the accompanying reproductions of the drawings of it and of photographs of the work in progress. The caisson consists of a tight timber box 32.5 ft. wide, 51 ft. 8 in. long and 18 ft. high over all, which is open at the bottom. It is separated into an upper and a lower compartment by a tight timber deck, 7 ft. 8 in. above the bottom, made of 4x12-in. plank. A second tight deck, made of 2x12-in. plank. is placed 12 in. above this lower deck and forms the floor of a watertight compartment, 14.5 ft. deep, over the lower compartment.

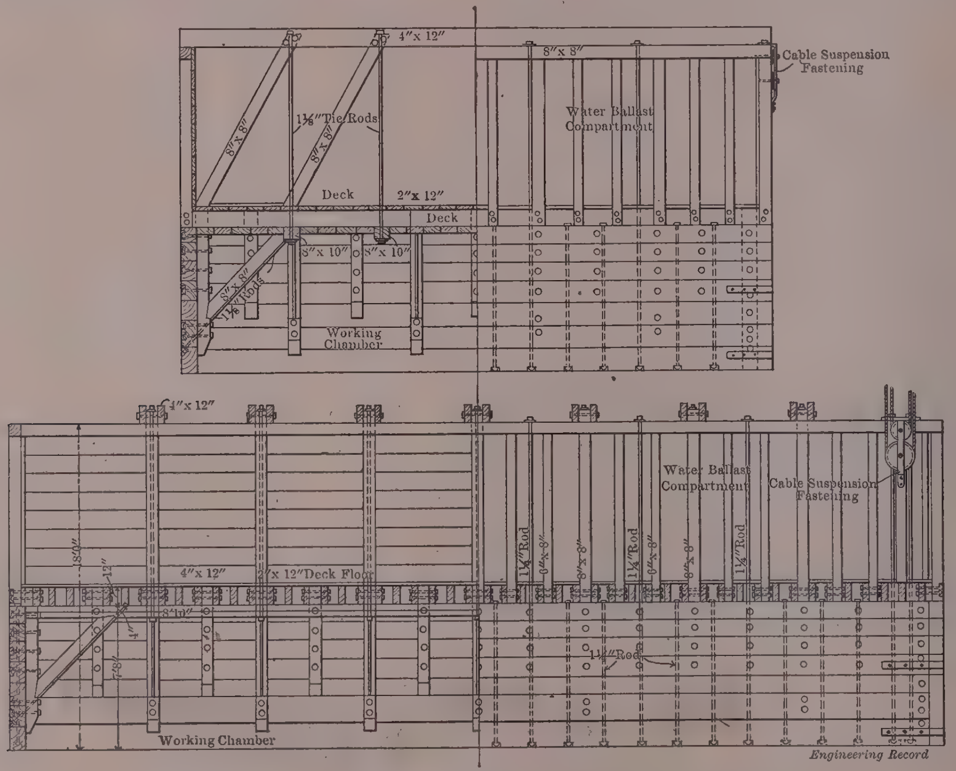
The lower compartment is open at the bottom and forms the working chamber of the caisson. Its sides and ends are made of 10-in. timbers laid horizontally and fastened together by 1¼-in. vertical tie rods every 2 ft. around the walls These vertical tie rods extend up to the top of the walls of the working chamber, every third rod extending up to an 8x8-in. timber at the top of the upper compartment. The top 8x10-in. timber on each side is tied to the one on the other side at each tie-rod by a cross timber tie made of two 4x12-in. planks. The sides and ends of the working chamber are braced by knee braces against cross timbers in the ceiling or lower deck, and against vertical timbers in the walls of the caisson. The upper compartment is built to carry water ballast. Its deck rests on 4x12-in. transverse timbers between the two decks. These timbers are carried by longitudinal 8x10-in. girders in the deck of the lower compartment. The girders are carried by tie rods which form the tension members of transverse Howe trusses built up in the upper compartment.

The caisson is operated on the general principal of the old style diving bell. It is very much lighter than a regular diving bell of the usual type having the same size could be made, as may be seen from the accompanying sections of it. The hoisting machinery required to raise and lower it is correspondingly reduced in weight. At the same time, very much smaller barges can be used to steady the caisson when it is lowered and to support it when raised. The ballast necessary to sink the caisson below its regular flotation level is supplied by water pumped into the compartment over the working chamber by a 12-in. Lawrence centrifugal pump. The weight of the caisson and ballast is largely counterbalanced by the air pressure in the working chamber. In order to insure stability of the caisson and to prevent any possibility of its being overturned by an excess of the upward air pressure in the working chamber over the weight of the caisson and water ballast, it is placed between two barges which are fixed firmly and rigidly together, and its weight and the weight of the ballast in it are partially carried by these barges under all conditions.

The barges are each 28x56 ft. in plan and 5.5 ft. deep, one of them being placed on each side of the caisson. The barges are fastened together at each end by a heavy Howe truss. These two trusses extend the width of each barge and span, the space between the barges. A heavy cross truss is placed on the side of each barge next to the caisson, extending from one to the other end truss. The two barges are thus held rigidly parallel and far enough apart to provide sufficient clearness for the free vertical movement of the caisson. The lower edge of the working chamber of the caisson has been sunk as much as 18 ft. below the surface but the average depth of submergence is about 15 ft. When the caisson is loaded with sufficient water ballast to sink it to the normal depth it has a total weight of about 800 tons. Of this weight all but 25 to 50 tons is counterbalanced by the air pressure required to lower the water level in the working chamber. The unbalanced portion of the weight is carried by the trusses between the barges, which are designed for a load of 100 tons with a factor of safety of 3. Each corner of the caisson is suspended from the trusses by eight part tackles with ⅝-in. steel hoisting rope, the four ropes leading to a special four-drum hoisting gear operated by a worm, which in turn is connected to a small marine engine. The hoisting gear is located at the center of a deck over the water ballast compartment of the caisson. The portion of the weight of the caisson unbalanced by the air pressure in the working chamber is transmitted to the trusses by these cables. The trusses distribute this weight over the ends of the barges thus holding the latter horizontal. The cables and hoisting engine are also used to a certain extent in lowering and raising the caisson, but the vertical movement of the latter is largely controlled by regulating the air pressure in the working chamber and the amount of water in the ballast compartment, as will be explained later.

The working chamber of the caisson was built on ways on the bank of the river and launched into the water when finished. It was built with a temporary bottom which was removed when the barges had been placed on each side of it and the trusses connecting the barges built. The piles under the grillage of the wall along the river front are in transverse bents, 2 ft. 10¼ in. on centers, the piles in the bents being 3 ft. to 4 ft. on centers from the stream to the land end of the bents. The grillage has a total width of 46 ft. so that the ends of the working chamber of the caisson clear the sides of it when the caisson is placed across it.

When the caisson and barges had been assembled together they were floated to position over the piles that had already been driven to Elevation 17.0 by the floating drivers. The cutting edge of the caisson was then lowered to Elevation 15.0 by pumping water into the ballast compartment and by slacking away on the tackles attached at each corner of the caisson, 11 bents of the piles being covered by the working chamber. Air under pressure was then admitted to the latter, forcing the water level in it down until a water seal of 2 to 4 in. remained on the inside. The piles were then cut off at Elevation 15.74 by hand by men working on staging swung from ring bolts in the deck over the chamber, or on staging on the piles. This same method of cutting the piles was followed in all the work. During the early stages of the work somewhat different methods were employed in the under-water operations from the methods afterward developed, but as they differ only slightly from the latter, the final methods only will be explained.

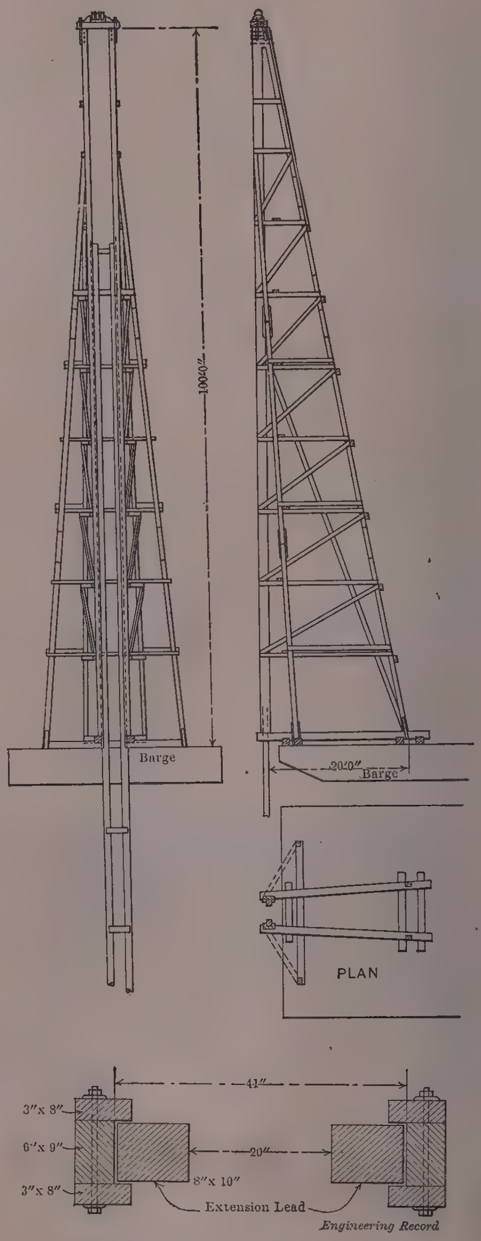


Sections and Elevations of Special Pneumatic Caisson.

The pile bents inside of the chamber were capped when they had been sawed off at the proper elevation. The grillage timbers were laid on and drifted to the pile caps, the ends of the grillage timbers were not extended beyond the cap on the pile bent on the side of the chamber farthest from the completed work and some of them were not extended to this bent. When this much of the grillage had been laid, the caisson was then raised by opening sluice gates in the sides of the ballast compartment, which permit the water to flow out of the compartment, and by hauling on the cables. When the cutting edge was high enough to clear the grillage already laid the barges and caisson were moved along the piles until the rear cutting edge had been brought to the position just occupied by the front edge. The caisson was then lowered over the piles again, the pile bent which had been capped and beyond which the grillage had not been extended in the first operation coming just outside of the rear cutting edge of the working chamber. The 11 bents included in the chamber after this move were then sawed off and capped and the grillage laid on the caps in the same way as in the first operation. The caisson was next raised and moved back over the work until it covered the space between the two operations over which no grillage had been placed and in which the rear cutting edge of the chamber had just been resting. The caisson was then lowered until its side cutting edges rested on the grillage already laid. Care was taken in laying the grillage to leave timbers ending on different caps so when the space between the sections was filled in the whole grillage would be well bonded together. The work was then continued in this series of operations until the grillage had all been laid.

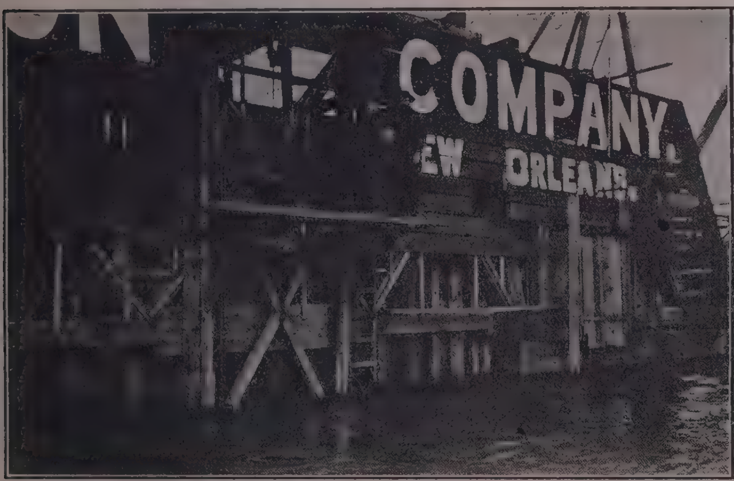
The caisson and barges are moved along the work and held in line by cables on a row of guide piles driven on the land side of the grillage. A Lidgerwood hoisting engine, with two spools and two drums, is mounted on one of the barges. A cable on one of the drums passes around a sheave on the end of the barge next to the row of guide piles, then around a sheave attached to one of the upstream guide piles and is attached to the opposite end of the barge. By hauling and slacking on this cable, the caisson and barges are moved up and down stream, respectively. The caisson and barges are held away from the guide piles by a log boom 20 ft. long on the upstream side of the barge. One end of the boom is lashed to the upstream land corner of the barge; the other end carries a sheave. The boom extends across the line of the guide piles. A cable on one of the spools of hoisting engine passes around sheaves on the barge, then around the sheave on the end of the boom and is attached to a pile just above the barge. By hauling and slacking on this cable, the barge is pushed away from, or allowed to approach the guide piles. A duplicate arrangement of cables on the other barge controls the position of the other end of the caisson and barges.

The same barge on which the hoisting engine is placed carries a 40 and an 80-h.-p. steam boiler, a 12-in. Lawrence centrifugal pump and an 8x12-in. compound duplex pump. The other barge carries a 7½-kw. electric generator and 3 air compressors. The boilers supply steam to operate the entire mechanical plant, one being held in reserve. Two distinct steam connections are made between the boilers and the machinery on the other barge and connections are also made so steam may be supplied from the boiler of any one of the adjacent pile-driver outfits. The 12-in. centrifugal pump supplies water to the ballast compartment of the caisson. The other pump is used in jetting out mud where the river bottom is above Elevation 15.0. The electric generator furnishes power for lighting, the working chamber of the caisson also being electrically lighted. One of the air compressors is run at high pressure to operate pneumatic tools in the working chamber. One of the other two supplies air at low pressure to lower the water level in that chamber, the third one being held in reserve and all three being available for maintaining air pressure in the working chamber.



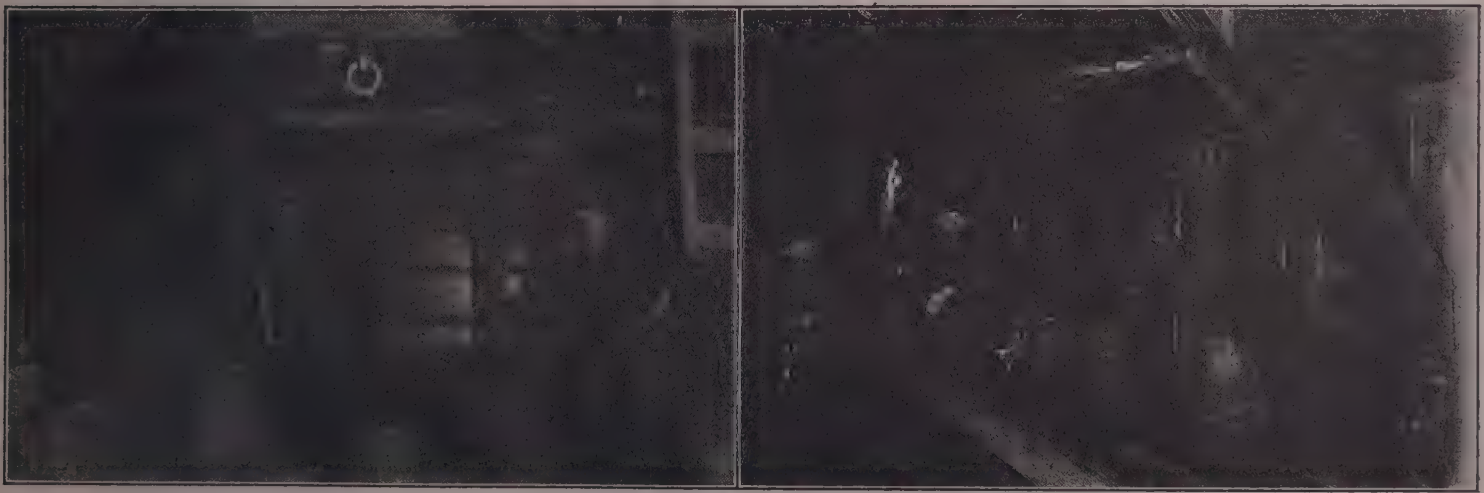
Pile Driver used at Chalmette.

A timber lowering arrangement has been used to great advantage in taking the pile caps and grillage timbers into the working chamber. A pair of vertical timber ways extending down to the cutting edge of the working chamber, were attached to one of the trusses. A sprocket wheel was placed at the top and bottom of each of these ways and a link-belt sprocket chain operated on each vertical pair of sprockets, the chains being 7 ft. apart horizontally. A bracket was attached to each chain at the same level. The horizontal arms of these brackets were placed down and fitted with a pair of small spikes to prevent the timber from slipping under the brackets. By moving the chain and lowering these brackets a timber can be submerged by the latter, and as the brackets pass around the lower sprockets they deliver the timber under the cutting edge into the chamber. The ways had to be placed out from the caisson a little at the top in order to secure the proper adjustment of the sprockets and chains at the bottom along the cutting edge. The timbers used in the under-water work could thus be taken into the chamber in any lengths from 7 to 28 ft., and all difficulty of passing them through the locks was avoided.



Timber Lowering Device on Side of Caisson.

Caisson and Barges Moored Along Guide Piles.



Two Views in the Working Chamber of the Caisson Showing Pile Heads to be Sawed Off.

A pneumatically operated trolley was used to handle the timbers in the working chamber. An 8-in. I-beam was bolted along the longitudinal center line of the ceiling of the chamber and carried a specially designed pneumatic hoist built by the Chicago Pneumatic Tool Co. This hoist could lift its load to within 2 ft. of the ceiling and travel the full length of the chamber. It was provided with timber hooks and was of much service in handling the heavy timbers. Pneumatic boring machines and hammers were also used in boring for and driving the drift bolts.

A total of 5,000 piles covering a total length of 1,100 ft. along the river have been sawed off and capped and the grillage placed on them in the caisson without an accident in the working chamber or to the plant. A large number of sea-going vessels pass up and down the river, causing high waves in the latter. These waves have never interrupted work in the caisson and have had no appreciable effect on the stability of the combined caisson and barges, owing to the weight and mass of the arrangement. The waves cause an increased strain to be brought on the cables attached to the corners of the caisson, but the water ballast steadies the whole structure. The water ballast compartment has been divided into 3 transverse rows of 3 equal sections, and 3 longitudinal rows of 3 equal sections, making 9 compartments in all, each controlled by a sluice gate. The centrifugal pump delivers to the central section and the other sections are supplied from this section through their sluice gates. Any unequal settlement of the caisson can thus be readily overcome by changing the amount of water being supplied to or taken from any section. The air pressure in the working chamber ranges from 4 to 7 lb., depending on the depth of submergence. No difficulty has been experienced from the air blowing under the cutting edge. Just enough leakage occurs at this point to secure good ventilation of the chamber and to require one of the compressors to be kept slowly turning over. Two air locks were provided for emergencies, although only one is used.

The concrete in the retaining wall is to be built on the grillage outside of the levee and will be placed under water to a depth of not to exceed 6 ft., and the portion of the concrete walls back of the levee will be built in the dry. In order to secure 30 ft. of water in the slip at the lowest stage of the river 700,000 cu. yd. of earth will have to be excavated between the freight houses. This is to be removed with hydraulic dredges and will be used to raise the grade of the yards of the terminal to just above the high water stage in the river. The terminal is to be completed and in operation by May 1, 1907. The work for which contracts have already been awarded requires an expenditure of $3,000,000. It includes, among other things, 30,000 piles, 150,000 cu. yd. of concrete and 5,150,000 ft. board measure, of permanent timber construction, and 5,000 tons of structural steel.

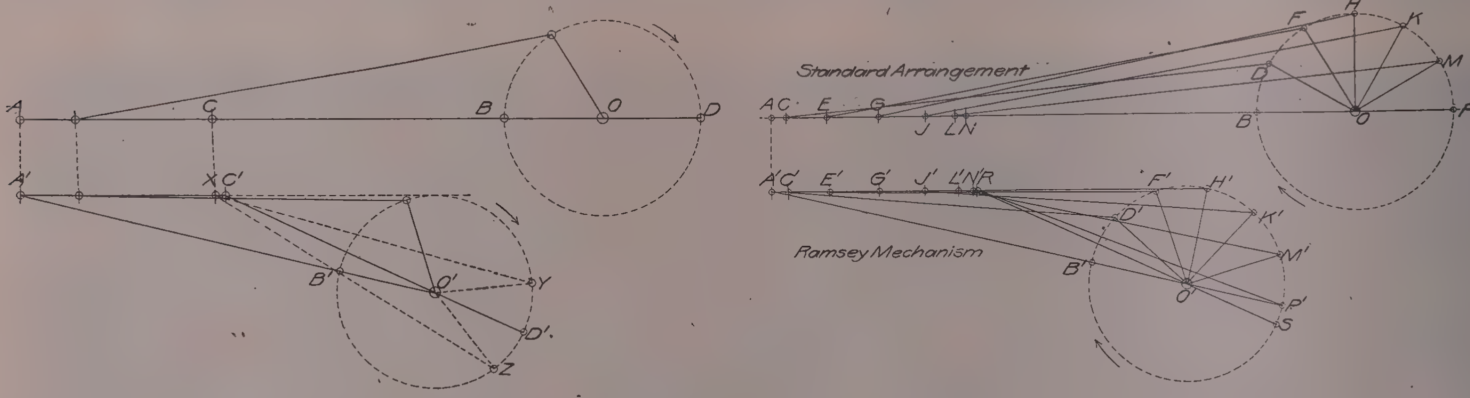
The contract for the construction of these terminals was awarded about a year ago to James Stewart & Co., of New York, general contractors, who sublet that portion of the slip walls outside of the levee to The Foundation Co., of New York. The officials of the New Orleans Terminal Co., having charge of the work for the owner are Mr. L. S. Berg, president; Captain J. F. Hinckley, chief engineer; Mr. A. L. Phillips, assistant chief engineer, and Mr. F. G. Jonah, resident engineer. The work of the Foundation Co. is in charge of Mr. Louis R. Barras as superintendent and Mr. Lee Treadwell as engineer.

A 5,000-kw. Steam Turbine of the Curtis type at the Fisk St. station of the Commonwealth Electric Co. of Chicago was recently tested after running in commercial service for about a year. The tests were made by Messrs. Sargent and Lundy. At 500 r.p.m., the water rate, reduced to 150° superheat, 1½ in. back pressure and 175 lb. gauge pressure was as follows: ½ load, 17.74 lb.; ¾ load, 17.08 lb.; full load, 16.62 lb.; 1¼ load, 16.52 lb.; 1½ load, 16.90 lb. The water rate at 650 r.p.m., 150° superheat, 1½ in. back pressure and 175 lb. gauge pressure, was 16.35 lb. at ¾ load; 16.07 at full load; 15.88 lb. at 1¼ load; and 15.80 lb. at 1½ load.

An Improved Crank Mechanism for Single-Acting Engines.

With the greatly increasing use of the internal combustion engine, both for stationary power and for vehicle driving purposes, the single-acting type of engine with trunk piston has prevailed almost exclusively. Numberless attempts have been made to improve the cylinder, valve and ignition mechanism design, but little attention has been paid to the crank mechanism, and it is accordingly interesting to note an important departure in crank arrangement that has been perfected for single-acting engines, by means of which both the thermal and mechanical efficiencies are considerably improved. This new principle, which is known as the Ramsey crank mechanism, is a modification of the reciprocating engine mechanism that varies the usual relative arrangements of cylinder axis and crank shaft, by means of which a number of important advantages are secured, especially for the internal combustion engine. It is applicable to reciprocating engines for all kinds of motive power, but only those that are single-acting.

In ordinary reciprocating engine design the central axis of the cylinder is placed in line with the crank shaft and the connecting rod is usually made approximately five times the length of the crank. To make the connecting rod shorter introduces excessive cylinder friction because of the sharp angularity of the connecting rod during the power stroke. The Ramsey crank mechanism, however, departs from usual practice, in that the connecting rod is made approximately three and three-eighths times the length of the crank, and the crank shaft is offset from the central axis of the cylinder a distance equal to the length of the crank, so that the direction of action of the piston during the power stroke is tangent to the circle of crank motion. The use of the short connecting rod with this arrangement is not only practicable, but also highly beneficial, as will be shown.

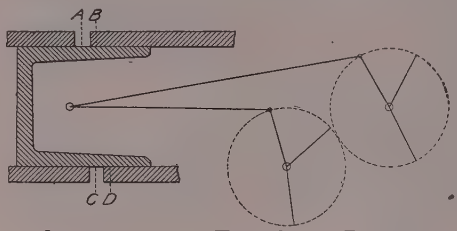


Diagrams showing Operation of Ramsey Crank Mechanism as Compared with Standard Crank Arrangement.

The first notable effect of the Ramsey design is to increase the length of the piston stroke as compared with the ordinary engine of similar dimensions, and to increase the proportion of the crank circle during which effective pressure is applied by the piston to the crank. Thus, as illustrated in an accompanying drawing, letting *AB* and *BO* represent the positions of an ordinary connecting rod and crank at the beginning of the power stroke, and *CD* and *DO* the positions of the same at the end of the power stroke, *AC* represents the piston stroke, which is equal to the diameter of the crank circle. During this stroke the crank covers exactly one-half of its circle, or 180 deg. In the same figure let *A'B'* and *B'O'* represent the positions of the connecting rod and crank of the Ramsey crank mechanism at the beginning of the power stroke, and *C'D'* and *D'O'* the positions of the same connecting rod and crank at the end of the power stroke; *AXC* therefore represents the piston stroke, which exceeds by about 5.25 per cent. the diameter of the crank circle, while the crank pin has been driven from *B'* to *D'*, a distance amounting to 192 deg. of the crank circle, or 12 deg. more than one-half of the circle.

The effect of the longer piston stroke is to increase the expansion of the gases for an engine of given dimensions, which not only increases the power to be obtained from it, but also the efficiency and economy with which it is operated. The gain in effective crank travel similarly increases the power that can be obtained from an engine of given dimensions.

In another drawing is presented a comparison of the Ramsey principle with the ordinary engine crank mechanism. At the inner dead center no angular relation exists, in the ordinary mechanism, between the connecting rod and the central axis of the cylinder, and therefore the only friction between the piston and the cylinder is that due to the weight of the piston itself; immediately after passing the inner dead center, however, the connecting rod assumes an angular relation to the central axis of the cylinder which increases very rapidly. In the position *CD*, after 30 deg. of crank travel, the angle existing between the connecting rod and the central axis of the cylinder is 6 deg.; in the position *EF* this angularity equals 10 deg. +, and in the position *GH* it reaches its maximum of 12 deg. In the succeeding positions, *JK* and *LM* the angularities are 10 deg. + and 6 deg., respectively, and when the outer dead center is reached the angularity has again decreased to zero. In each of these positions the friction between the piston and the cylinder wall is the result of the angular thrust exerted by the connecting rod, and therefore the greater the angularity—pressure and velocity considered—the greater will be the friction.



Application to Two-Cycle Engine.

Comparing this with the angularity existing between the connecting rod and the central axis of the cylinder in the Ramsey crank mechanism, we find that at the inner dead center, in which position the connecting rod is shown as *A'B'*, the angularity equals 13 deg.. As the piston travels outward on the power stroke, this angularity rapidly decreases, instead of increasing as in the case of the ordinary crank mechanism. When the connecting rod reaches the position, *C'D'*, after 30 deg. of crank travel, the angularity has decreased to 5 deg.; in the position *E'F'*, it has decreased to 1 deg., while between the points *E'* and *G'* when the piston is traveling at its maximum speed and the crank is in the most favorable position for transmitting the power delivered to it, the angularity is practically zero and a straight thrust is obtained through a considerable portion of the stroke. In the succeeding positions, *G'H'*, *J'K'* and *L'M'*, the existing angularities are, respectively, ½ deg., 4 and 11 deg. In the position *N'P'* at which point the crank has traveled one-half its circle, the angularity has increased to 21 deg., while at its outer dead center, shown as *RS*, the angularity is 25 deg.; but at these late points very little friction is caused by the greater angularity since but comparatively slight pressure is exerted on the piston and the distance traveled by the piston is small. The most favorable angularity at which the ordinary crank mechanism has any considerable piston travel is between 6 and 9 deg. At this angularity of the rod, the Ramsey mechanism has three times as much piston travel as has the ordinary crank mechanism. Making the comparison still another way, the Ramsey crank mechanism has more piston travel at less than a 1 deg. angle than has the ordinary crank mechanism at less than a 9 deg. angle.

The comparative angularities for each position of the piston is worth careful study. Only at the extremities of the stroke does the angularity of the ordinary mechanism compare favorably with that of the Ramsey crank mechanism. From the positions *C* and *C'* to the positions *L* and *L'*—which include by far the greater part of the stroke—the Ramsey mechanism shows a tremendous advantage in connecting rod angularity over the ordinary mechanism. Reducing the relative travel of the two pistons to a percentage basis, the results in Table I are secured—these percentages holding good for any length of crank:

Table I.

Comparison of Piston Travel.

	Ramsey Crank Mechanism, Per cent.	Ordinary Mechanism, Per cent.
Travel during the power stroke at less than a 10 deg. angle......	88	50
At less than a 9 deg. angle.......	85	30
At less than a 6 deg. angle.......	73	13¼
At less than a 3 deg. angle.......	50	3¼
At less than a 1 deg. angle.......	31	1¼

A very unique and valuable feature of the Ramsey crank mechanism is the sluggish movement imparted to the piston at the beginning of the return stroke. Letting the distance *A'C'* represent the piston stroke of an engine equipped with the Ramsey crank mechanism; and the line *A'X* the part of the stroke that would correspond to the full stroke of an ordinary engine having the same length of crank, it will be seen that from the time the piston of an engine mounted on the Ramsey principle passes the point *X* on its outward stroke and returns to this point on the return stroke, the crank travels from the point *Y* to the point *Z*, a distance equal to 60 deg. of its circle, or one-sixth of its entire path. This sluggish movement of the piston makes it possible to exhaust the burnt gases with considerable less back pressure than that which is inevitably in an ordinary engine.

Many manufacturers of gas and gasoline engines, who have appreciated the advantages of an auxiliary exhaust port, have hesitated to introduce this valuable feature in their engines because of the off-setting disadvantages involved when the ordinary crank mechanism is employed. The most formidable of these disadvantages—and, in fact, the only one which it has not been possible to overcome as yet—is the necessity of sacrificing a part of the power stroke for the operation of the auxiliary port. This disadvantage is entirely eliminated by the Ramsey crank mechanism, since the increased piston stroke and the sluggish piston movement at the outer extremity afford ample time for both the auxiliary exhaust and the main exhaust to be operated after a power stroke to the full diameter of the crank circle.

In the case of a two-cycle engine this sluggish movement presents a further advantage, in that less of the power stroke need be sacrificed by the opening of the exhaust port, while at the same time giving a greater period for voiding the exhaust gases, and thus enabling the engine to be run at a higher speed. In an accompanying engraving is shown the Ramsey crank mechanism in comparison with the ordinary crank mechanism when operated with the cylinder of a two-cycle engine common to both mechanisms. The exhaust port in the upper side of the cylinder, and the inlet port in the lower side, are so located as to give sufficient time for scavenging and recharging the cylinder of an engine equipped with the ordinary crank mechanism. In a two-cycle engine equipped with the Ramsey mechanism, if the exhaust valve is placed at *AB* and the inlet valve at *CD*, the effective power stroke will be increased more than 8 per cent., while, owing to the sluggish movement of the piston above referred to, the same period of time will be provided for scavenging the cylinder and re-charging it with fresh gases.

After the piston passes the point of its sluggish movement it returns to the inner end of its stroke very rapidly. In the last 120 deg. of crank travel the piston moves a distance equal to 81.4 per cent. of its stroke, as compared with 138.5 deg. of movement for the ordinary crank to cover a like percentage of its stroke. This rapid return of the piston during the compression of the fresh gases minimizes the loss of heat by radiation during compression, and thus increases the temperature and pressure in the cylinder at the time of ignition, correspondingly increasing the initial pressure of the power stroke.

The short connecting rod used with the Ramsey crank mechanism, which is made practicable by the position of the crank shaft, reduces the length of horizontal engines, or the height of vertical engines, in the following proportions:

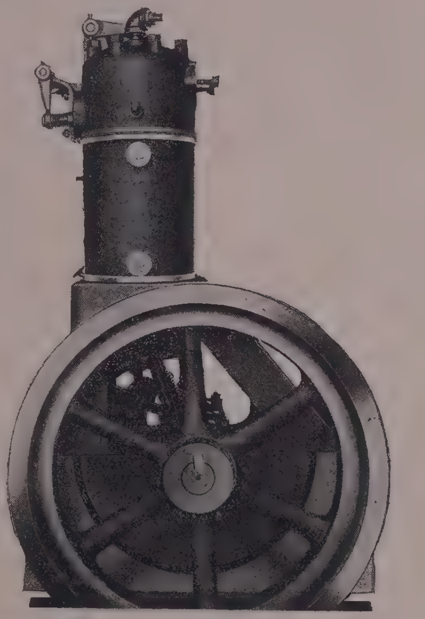
Length of Cr'k, in.	2	3	4	5	6	7	8	9	10
Length Saved, in..	3½	5¼	7	8¾	10½	12¼	14	15¾	17½

This feature of compactness, is of particular value in automobile and marine engines, or wherever floor space or head room is limited.

One of the most interesting features of the Ramsey mechanism is that it can be adapted to any single-acting engine of present design without in the least interfering with the special features of such an engine. Regardless of what an engine designer's ideas are as to carburetors, valves, valve mechanism, igniters, lubricating devices, etc., it can be applied to any engine without necessitating the abandonment or alteration of its other parts. It adds no new parts to an engine and involves no complications. On the other hand, it reduces the cost of the connecting rod forging, and by shortening and compacting the engine as already pointed out, it reduces the weight of the engine and the amount of metal required for the engine frame.

Several engines equipped with the Ramsey crank mechanism have been built and tested and have shown remarkable results, but these tests must be considered in their true relation to be of value. To determine to what extent the Ramsey crank mechanism will improve the efficiency of an engine it is obvious that the comparison must be made between two engines of approximately the same design, and, for the purpose of making such a comparison, an engine was constructed and equipped with the Ramsey mechanism on the lines of a well-known vertical marine gasoline engine having a 9½ x 14-in. cylinder. The manufacturers claimed for their engine a fuel consumption of 1/8 gal. of gasoline per horse-power hour, while in the tests made of the engine equipped with the Ramsey crank mechanism the fuel consumption was found to be from 1/10 to 1/11 of a gallon per horse-power hour.

In a series of tests made of this engine under the supervision of the University of Pennsylvania, working under brake loads varying from 22 to 30 h.-p., the total efficiency of the engine ranged from 24.1 to 25.9 per cent. These figures refer to the total heat efficiency, that is, the ratio between the total heat supplied to the engine and the heat accounted for in useful work. This compares with a total efficiency of approximately 19 per cent. for the engine equipped with the ordinary crank mechanism after which the test engine was patterned. So far as is known, the results obtained in these tests greatly exceed the results obtained from any other gasoline engine of anything like similar size.



Gas Engine Fitted with Ramsey Crank Mechanism.

As the efficiency of an engine may be improved by changes in the design, without reference to the crank mechanism employed, this efficiency can still be increased by the Ramsey crank mechanism. In other words, the advantages of the increased expansion, the greater piston stroke and crank effort, the decreased friction, the sluggish movement and quick compression, will materially benefit the efficiency of any engine without regard to the excellency of its other features.

The Ramsey crank mechanism is the invention of Mr. Robert H. Ramsey of Philadelphia, who for a number of years has been making a special study of the subject. The device is covered by patents in the United States and a number of foreign countries. The domestic patents are controlled by the Ramsey Engine Co., with offices in the Bullitt Bldg., Philadelphia, and they will issue licenses to manufacturers of single-acting engines in this country.

Report of the Board of Advisory Engineers of the Sewerage Commission of Baltimore.—II.

The plan recommended by the Advisory Board of Engineers is purification by septic tanks and sprinkling filters, with supplementary settling and intermittent filtration. This method of purification, as applied to works located on Patapsco Neck near Back River, is outlined in the accompanying illustrations, and comprises the following principal steps:

1. The deposition in large basins of the coarse matters suspended in the sewage and which, as a rule, have a specific gravity greater than that of water.

2. The accumulation of the sludge (the deposited solid matters) on the bottom of the basins under conditions facilitating bacterial activity as to liquefy and gasify, so far as possible, the solid organic matters in the sludge. This bacterial process is known as "septicization," and converts the ordinary settling basin into the so-called "septic tank."

3. The disposal of the residual sludge from septic tanks upon land, in such manner that its water is quickly reduced by evaporation and filtration and that the resulting fairly dry humus and mineral matter is inodorous and inoffensive.

4. The application of the partially clarified sewage coming from the septic tanks to areas of broken stoine, called "sprinkling filters," in the form of spray, under such conditions that the remaining putrefying organic matter in the sewage is so acted upon that the effluent from the sprinkling filters will not be puetrescible, and so that the bacteria in the sewage will be largely eliminated.

5. The deposition in small, settling basins of the coarser suspended particles contained in the effluent of the sprinkling filters and coming for the most part as films detached from around the broken stone in the sprinkling filters.

6. The supplementary treatment of the clarified and non-putrescible effluent of the sprinkling filters, after it leaves the settling tanks by means of intermittent filters.

Works having a normal capacity of 75,000,000 gal. daily would require structures to carry out the full steps above mentioned substantially as follows: Septic tanks, holding eight hours' storage, having a maximum depth of 12 ft. and having an area of about 400 by 800 ft.; sprinkling filters comprising 30 acres in area of broken stone averaging about 9 ft. in depth; supplementary settling tanks, holding three hours' storage, having a depth of 10 ft. and covering an area of about 300 by 500 ft.; and intermittent sand filters having a net area of 100 acres.

Together with these various structures there would be required numerous conduits, drains, gates and other appurtenances, as will be appreciated from the following description of the more essential features in the construction and operation of the works.

Septic Tanks.—The first purpose of the septic tanks is to cause a deposition of those matters suspended in the sewage which settle to the bottom of the tank when the liquid is brought to rest or when its velocity of flow is very greatly reduced. Experience shows that with a sewage such as may be expected at Baltimore, about two-thirds of the suspended matters may be deposited when the sewage is allowed to flow through suitably arranged tanks for a period of six hours or so. Available evidence indicates that the velocity of flow should be reduced on an average to about four millimeters per second, or ten inches per minute. With basins having a length of flow of about 400 ft. the sewage at about such velocities is generally clarified on an average about as much as economy permits for this step in the process. The depth of liquid in the tanks will be 12 ft. for the maximum. To facilitate as uniform an hourly rate of flow of the sewage to the sprinkling filters as possible, it is assumed that the depth of the sewage may be allowed to fluctuate between twelve and nine feet. In computing the actual net velocity of flow it is necessary to bear in mind that accumulating deposits on the bottom of the tanks will somewhat reduce the available storage depth. To facilitate operations when the works are first built and the quantity of sewage is quite small, and in order to allow of portions being conveniently cleaned, the tanks should have division walls making five and preferably more compartments.

Along the inlet and outlet ends of these tanks there are conduits with suitable branches and gates connecting with each tank. Transverse walls extending to a height of about 8 ft. guard against sludge being moved toward the outlet at times of unusually heavy flows. Floating baffles also guard against scum passing with the sewage into the outlet conduits. The bottom of the tanks slopes to sumps connecting with convenient drains for cleaning. Water under pressure for flushing is also provided.

So far as the Board considers it is able to judge, the septic treatment under conditions to be expected at Baltimore will not materially affect the character of the settled sewage passing from the tanks. In fact, the septic treatment relates essentially to the condition and disposition of the sludge. The sludge may be allowed to accumulate for months or perhaps years. Under these circumstances the bacterial action occurs, and on an average probably more than one-half of the total deposited matter would be converted into a liquid or gaseous form. As the bacteria do not attack the solid mineral matter, it is the solid organic matter which is affected. The latter should be acted upon until it contains no more organic matter which will putrefy either in the septic tank or after its removal. The septic treatment, therefore, reduces materially the volume of sludge, and causes the latter, when the septic tanks are properly operated, to become practically inert mineral and humus matter. Septicization is practiced to best advantage when this effect upon the sludge is accomplished, and when the septic effluent shows a minimum effect of this bacterial action. The Board considers this latter requirement imperative and have so regarded the matter in this report, both as to the construction and operation of septic tanks.

This septic treatment results in the generation of a substantial quantity of gas composed principally of marsh gas. The rate at which the gas is evolved, roughly measures the intensity of the bacterial action, and varies at different seasons of the year, depending largely on the temperature and somewhat on the kind of organic matter in the sludge and the bacteria present therein. This process continues during the winter weather, but is far more active during the warm season of the year. The gas thus evolved rises to the surface and at times carries up with it some of the sludge, thus forming a scum on the surface of the liquid in the basins. This scum is generally thicker in warm weather than in cold, and in many places it is almost absent during the colder season of the year.

The septic tanks are not provided with covers, as the latter do not facilitate the process except perhaps in climates far more severe than at Baltimore.

Based upon various experiences at numerous places, we have no reason to expect that objectionable odors would be encountered beyond a short distance from these tanks if the latter are well managed. The odors are carried the greatest distance on almost calm, muggy days in summer when there is no strong wind to disperse them. Under these conditions it is safe, in the judgment of the Board, to estimate that objectionable odors will not be carried to as great a distance as one-fourth of a mile.

Septic tanks in one form or another have been tried for many years and are now in regular use in more than thirty cities and towns in the United States, including Plainfield, N. J., Saratoga, N. Y., Mansfield, Ohio, and at numerous institutions. In Europe there are scores of septic tanks in operation, the largest installation being at Birmingham, the metropolitan district of which includes about 900,000 persons. The septic tanks at Manchester treat about an equal volume of sewage.

Manufacturing wastes have in some instances in this country and in Europe increased the odors from septic tanks, but the Board reports that it sees no reason for believing that such trade wastes as cannot be kept out of the sewers at Baltimore would be an important factor in this connection. Sea water contains substances which may combine with others in the sewage and produce odors. It should therefore be rigidly excluded.

Summing up the work performed in the septic tanks, it may be said that about two-thirds of the suspended matter and about one-third of the total organic matter will be deposited. In general the percentage of removal of bacteria in the incoming sewage approximates that of the total suspended matter, although growths of other bacteria in the sludge on the bottom of the tanks may disguise the degree of bacterial removal. This preliminary treatment obviously enables the effluent to be filtered at materially higher rates than the raw sewage with equal results as to quality of filtrate.

With sewage of the composition estimated for Baltimore, there would be deposited upon the bottom of the tanks in the neighborhood of 6 cu. yd. of sludge per million gallons of sewage in which there would be 90 per cent. or more of water. With favorable management the tanks may be operated so that this sludge will be reduced by bacterial action about one-half, and still further consolidation in the tank to about 2 cu. yd. per million gallons. The amount of water in the septic sludge would then be about 85 per cent.

The more important features of managing the septic tanks with reference to reducing the sludge and to disposing of it in the most advantageous matter, are next considered.

Sludge Disposal.—It is common experience that the depth of sludge accumulated on the bottom of septic tanks varies materially from time to time. Other things being equal, the quantity is greatest toward the end of cold weather and is least at the end of the period of maximum bacterial activity.

In various communities experiences differ in regard to odors in the disposal of septic sludge. Obviously this is due to the differences in the condition of the sludge itself, and the question naturally arises: What are the conditions for the successful disposition of septic sludge without odor? Without entering into a long technical discussion of this question, it may be said that success attends those efforts where the sludge is not removed from the septic tanks until all or nearly all of its organic matter has passed through the putrefying stage and become practically inert. Odors from normal septic sludge seem to be accounted for, largely if not wholly, by the fact that sludge has been removed where there still remains a substantial portion of organic matter in a putrefying rather than in a putrefied condition.

The tanks should be cleaned as far as practicable after or toward the end of a period of maximum bacterial activity when the organic matter of a putrefying nature is reduced to a minimum. In order to obtain the conditions above stated, namely, to have the sludge removed when the putrefactive process is practically completed and not in active operation, crude sewage should not be allowed to enter the septic tank for some time prior to the cleaning of it.

The most successful treatment of sludge by septic process on a large scale is at Birmingham, England, where from time to time nearly all of the sludge is now pumped to a depth of eight to ten inches over land where the water is allowed to disappear by percolation and evaporation.

The operation of removing the sludge at the site selected on Patapsco Neck near Back River would involve perhaps once a year or oftener, the removal of the fairly clean portion of the contents of each septic tank in turn, and then the flushing of the remaining sludge into drains which would convey it by gravity to adjoining low lands. The main drain or conduit would have branches to allow the proper distribution of the sludge in thin layers as above indicated. Furthermore, banks should be so arranged that this sludge, while drying out to perhaps one-half its volume, would not be washed by rains into adjoining waterways. By keeping the sludge field one-fourth of a mile away from frequently traveled roads it is our judgment that the sludge disposal would create no nuisance.

Sprinkling Filters.—The next step in the process of purification is to convert the partially clarified sewage coming from the septic tanks to a non-putrescible state, and to purify it as much as practicable. By non-putrescible is meant such a reduction in the quantity of the organic matter that what remains will not putrefy even when the liquid without any dilution is exposed for several days to the heat of the summer sun.

Sprinkling filters are an English adaptation of studies made by the Massachusetts State Board of Health at the Lawrence Experiment Station with gravel filters some fifteen years ago. As proposed for Baltimore, they consist in the application in the form of a spray of about 500 gal. of sewage daily to each square yard (2,500,000 gal. per acre) of filter beds composed of fairly coarse broken stone. The size of the stones should be large enough so that a free vertical circulation of air is insured, as the sewage trickles down over the surface of the filtering material and leaves its suspended matter to form films around the stones. In these films are large numbers of bacteria which, in the presence of the oxygen of the air, convert the organic matter to simpler and stabler compounds. The films on the filtering material are detached from time to time in a more or less irregular way, so that the effluent contains very noticeable quantities of fairly large suspended matter, to which the term humus has been applied.

As sprinkling filtere are the most important feature of the recommended plan, the Board refers as follows in some detail to the experimental and practical installations in this country and abroad which serve in part as the basis for our action.

In this country the type of filter has been studied experimentally at Lawrence, Mass., Columbus, O., Boston, Mass., and Waterbury, Conn. The longest series of experiments has been made at Lawrence under the immediate direction of Mr. H. W. Clark, chemist of the State Board of Health. These experiments, commencing in 1899, have been made with small filters, having an area of 1-20,000 of an acre, placed in a building where they have been protected from snow and to some extent from cold. Exclusive of some tests of short duration, 10 filters have been studied to determine the extent of the purification under varying conditions as to depth, size and character of filtering material, as well as to rate of filtration. The sewage was distributed over the filtering material with tipping trays instead of sprinklers. A large filter of this type, 17.5 ft. in diameter, has also been tested under the same direction in the town of Andover, near Lawrence.

The experiments at Columbus were conducted for about ten months, beginning in August, 1904, under the immediate charge of Mr. George A. Johnson, and the general supervision of Messrs. Hering and Fuller, consulting engineers. These experiments are of especial value in that the filters were not covered and were successfully operated throughout the unusually cold winter of 1904-5. There were six filters of this type, varying in diameter from 7.5 to 13 ft. and having generally a depth of 5 ft. The filtering material was broken stone, generally from 0.5 to 2 in. in diameter. The sewage was as a rule distributed with fixed sprinkling nozzles. After making these experiments the City of Columbus adopted this system and is now building sprinkling filter beds having a total area of 10 acres.

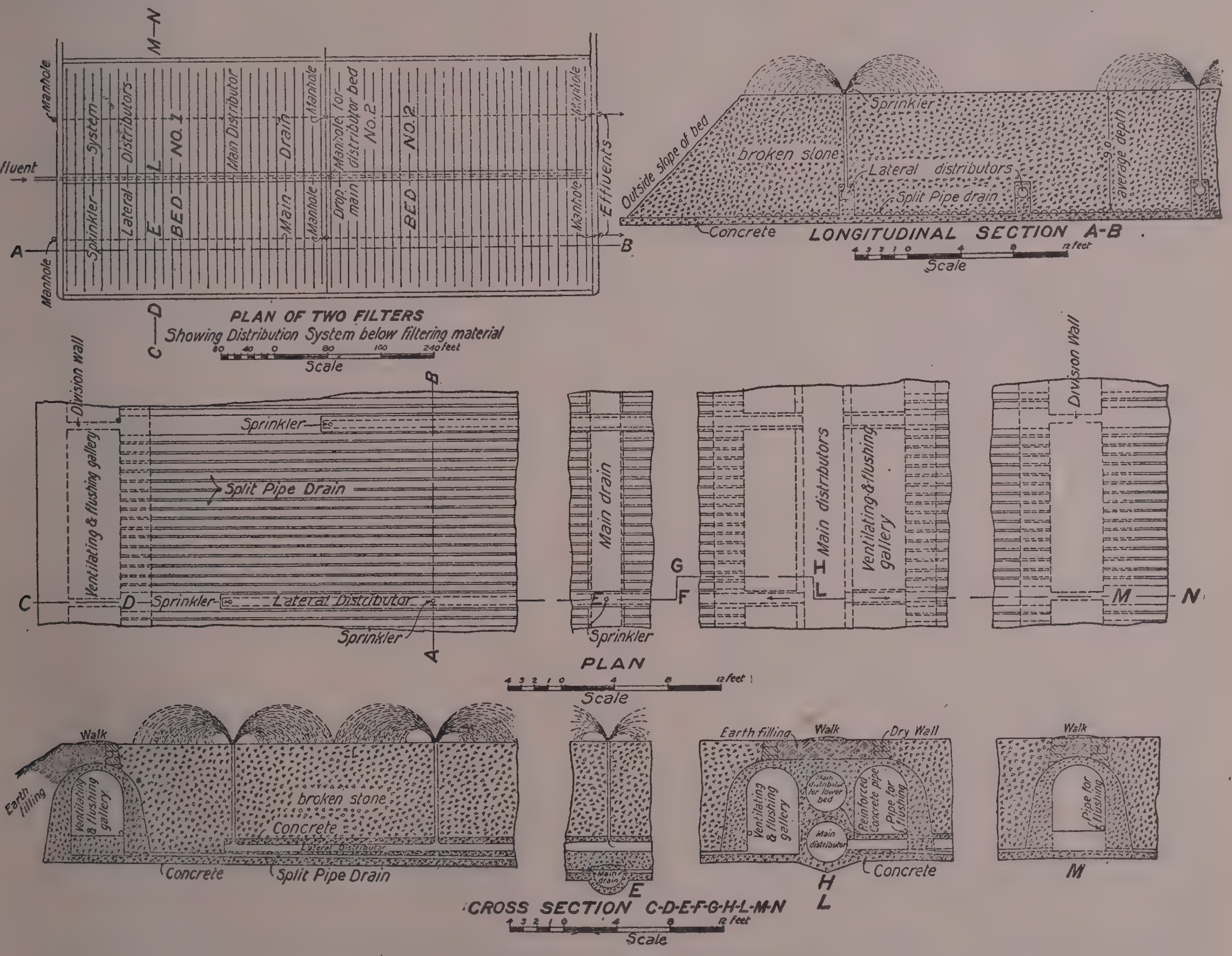
In Europe there has been much experimental work, some of it dating as far back as 1892. Of the many sprinkling filter system in practical use in England, those at Accrington, Birmingham and Salford are worthy of special mention on account of the large size of the installations or the long time that they have been operated.

The oldest filters of this type on a large scale are at Accrington, and they serve a population of about 50,000. The first beds were placed in operation in 1898 and other beds have been added from time to time until the aggregate area is now 15/16 of an acre. The filters which have been in service nearly eight years show as yet no signs of clogging.

The largest community up to this time to adopt sprinkling filters is that of Birmingham, which, with its suburbs, makes a metropolitan district of about 900,000 people. At the beginning of this year there were 6.5 acres of such filters in regular service. The sprinkling system is now being extended with a view to purifying all the sewage of the city by this process.

At Salford sprinkling filters were first constructed in 1899, and they have been added to gradually until the present area is about 7.5 acres.

At Huddersfield they have within the last few months placed a contract for the construction of a sprinkling filter plant of 10.5 acres.



Details of Construction of the Sprinkling Filters.

At Hanley a plant of this type of six acres is approaching completion. There are dozens of other sprinkling filter plants in England of interest and importance which it is not necessary here to mention.

On the continent of Europe there has been a good deal of experimental but not yet of executed work. In France the Department of the Seine has recently approved the recommendations of its engineers to install sprinkling filters for the purification of a portion of the sewage of the suburbs of Paris. In Germany this type of filter has been decided on for the purification of the sewage of some of the suburbs of Berlin, having a joint population of about 200,000 persons.

These facts show clearly that this type of filter has advanced well beyond what might be called the experimental stage of its development.

In one of the accompanying illustrations will be noted some of the more essential features of the sprinkling filters. The Board said it had not attempted to develop details of this project beyond the point of being able to ascertain the cost of devices which will do the work intended for them. The chief features are as follows:

The filters rest upon a concrete bottom about 6 in. in thickness, having a slope of about 1 ft. in 60 toward the underdrains for the collection and removal of the filtered sewage. Over this bottom is placed for drainage a series of half-round pipe with open joints, or perhaps special tile. The purpose of this free drainage is to get unobstructed channels for the removal of the effluent, which, as above stated, contains more or less fairly coarse suspended matter. Without such free drainage, even though only a part of the suspended matter in the effluent would be arrested, undesirable deposits would sooner or later be produced to clog the lower portion of the filter.

Over the drains is placed a thin layer of coarse stone, which in turn supports the main body of the finer stone. Its size should be as small as will allow a ready circulation of air through the material when the filter is regularly operated at its normal rate of filtration. This size, in the opinion of the Board, should be such that all stones can pass through a 2.5 in. and none through a 1-in. ring. Most of the experience in this country has been obtained with material finer than this, but experience in Europe and a limited amount of recent information in this country lead the Board to suggest for the first installment a coarser material than that tested at Columbus and which has been considered most successful at Lawrence.

The depth of sprinkling filters varies materially, but usually ranges from about 5 to 9 ft. The 5-ft. depth is apparently successful with material from 0.5 to 2 in. in diameter in producing a non-putrescible effluent and in removing some 70 per cent. of the bacteria in the applied sewage, such removal representing 90 per cent. of the bacteria in the crude sewage. Other things being equal, the deeper filters effect a more complete purification as regards organic matter and a more complete removal of bacteria, provided a sufficient amount of air is present throughout the filter. Under the conditions at Baltimore it is desirable to have the sprinkling filters purify the sewage very thoroughly, and we advise that the depth of material be made 9 ft.

The rate of filtration which may be successfully used with these filters depends considerably on the strength of the applied sewage. Experience at Lawrence and Columbus indicates that rates of about two million gallons per acre daily, on an average, may be safely adopted with ordinary American sewage containing much street refuse. With a separate system of sewers under the conditions at Baltimore the Board considers it safe to rate the capacity of these sprinkling filters in treating septic effluents at an average rate of about 2,500,000 gal. per acre daily. For a sewage flow of 125 gal. per capita daily, this is equal to about one acre of filter surface for each 20,000 of population connected with the sewers.

In one of the accompanying illustrations are shown some of the more important details as to the arrangement of the distributing pipes by which the septic effluent is applied to these filters. In general it is proposed to build a large concrete conduit from the septic tanks along the side of the filter beds. Branch pipes from this main conduit are placed at intervals to convey the sewage to each filter unit. From these branch pipes there are series of lateral distributing pipes spaced some 13 ft. apart. Spaced 15 ft. apart on these pipes are cast-iron rising pipes, extending to the surface of the filtering material. At the top of these risers, specially designed nozzles are attached, which, under a maximum head of some 7 ft., will spray the sewage over the filtering surface quite like the distribution of water by certain types of lawn sprinklers. We have adopted an arrangement of details similar in many respects to that which has been recently designed after a series of special studies for the works now building at Columbus, O. We therefore have the advantage, in estimating the cost, of bids recently received for those works.

We consider that it is highly desirable to have the spray applied as uniformly as possible over the entire area of the filter surface. With distributing nozzles it has been found by actual tests that when there is a variation of 3 ft. in the head at the nozzles, about 77 per cent. of the filter surface is covered with spray when no allowance is made for the effect of wind action. The latter, of course, materially increases the percentage of the surface covered. A short distance below the surface the rate per square foot would be still more uniform.

It is the opinion of the Board that it would be desirable to vary the head on the nozzles more frequently than once a day, which, in turn, would increase the uniformity of filtration. In fact, the Board thinks it would be advantageous to vary this head every few minutes, and advises that in preparing the final working drawings this feature of design receive special attention.

It is highly desirable in operating the sprinkling filters to be able to control the flow of sewage to each filter unit from a central point, and further, to be able to measure and record this flow. It is possible to accomplish this by rate controllers similar in type to those in use at several of the more recently designed mechanical filter plants for water purification. Under the circumstances at Baltimore, where it is necessary to conserve the pressure or head of the sewage so far as practicable, it seems to the Board that some other system of measurement and control would be more applicable. There are several ways by which this may be done, one of which would be to place a Venturi or other meter upon each branch pipe leading from the main conduit; to have a valve on each branch pipe operated from the central regulating house by electricity or otherwise; and further, to have the flow through these several meters indicated and recorded at the central house from which the operation of the filters would be directed by the attendants. These details have been studied only in so far as it is necessary to arrive at practicable procedures for purposes of estimates of cost.

The self-cleansing feature of sprinkling filters has already been mentioned, and in the cost estimate made by the Board the latter has assumed that the filtering material would require removing, cleaning and replacing on an average once in ten years, which from some European experiences may be too short. From time to time, however, attention would be required for removing deposits in the distributing pipes, and also below and around the drains.

The distributing pipes are made relatively large to facilitate a uniform distribution at the nozzles and to save head. Velocities are greater than in the septic tanks, but in time deposits would probably occur. At intervals it would be practicable to remove the nozzle from the rising pipe at the end of each lateral distributor and to allow the sewage to flow through a hose to a drain. The velocity thus created will remove all ordinary deposits. Still higher velocities can be obtained by discharging water under high pressure through a hose similarly connected. The unfiltered sewage thus removed from the distributing pipes would be conducted to a sump, from which it would be pumped back into the septic tanks for further treatment.

It will be seen in the illustration that no walls are provided at the ends of the filter units, but that along the sides and between the several filter units are walks beneath which are ventilating and flushing galleries. These galleries are some 6.5 ft. high and 4 ft. wide, with manholes at intervals of 100 ft. or so. As required, arrangements may be provided to assist ventilation, perhaps by building small structures over the manholes with openings which may be directed toward the prevailing wind.

In these galleries it will also be noted that at intervals of about 13 ft. are cross walls some 18 in. high. The purpose of these is to facilitate flushing the bottom of the filter beneath and around the tile drains. A system of pipes in each gallery conveys filtered sewage under pressure to all points where it may be conveniently used for flushing purposes. In addition to this flushing it may be necessary to dislodge the suspended matter by means of jointed swabs, thereby deferring the period of removing, cleaning and replacing the filter material. The galleries are of sufficient width to permit the use of such swabs.

There should be no objectionable odors from sprinkling filters properly managed noticeable one-fourth of a mile from the plant, and usually not more than a few hundred feet.

As to the degree of purification effected by the sprinkling filters constructed and operated as above indicated, the organic matter should be reduced so that at all times the filtrate will be non-putrescible. There should be at all times well established nitrification with fairly large quantities of nitrates present in the effluent. The effluent should at all times contain an abundance of dissolved oxygen. The suspended matter in the effluent should approximate on an average that of the septic effluent, with the important difference that in the sprinkling filter effluent the suspended matter will have been reduced to a substantially non-putrescible state while attached to the filtering material as films, and which films will be regularly removed from the filter effluent in the form of sediment. There would presumably be a removal of bacteria in the neighborhood of 95 per cent. of those in the crude sewage.

Settling Basins.—To remove from the sprinkling filter effluent the suspended matter which is of a fairly coarse nature, the effluent is allowed to flow at a comparatively slow velocity through settling basins holding on an average fully three hours' flow. The average depth of these basins is about 10 ft. They are divided into several compartments as required, so that one at a time could be drained and cleaned. These basins are not covered.

The sludge accumulating in the settling basins would amount to about 1 cu. yd. per 1,000,000 gal. of sewage. The bottom of the basin is sloped so as to facilitate the removal of sludge so far as practicable. "Dortmund tanks" at Birmingham and a number of recently designed settling tanks in Germany have bottoms sloped sufficiently toward numerous sumps, so that the sludge may be removed at frequent intervals by opening a gate on the drain pipes, and thus allowing the head of water in the tanks to force the sludge to the point of disposal. The financial practicability of this method depends largely upon the exact soil conditions at the site selected. The Board stated that it had discussed the matter in some detail, but the data available are inadequate for it to arrive at a conclusion showing whether the bottom of these tanks may be made of special design so as to reduce the cost of sludge disposal. The construction cost would be increased above that given in the Board's estimate, and the plan should be adopted only in the event that there will be a corresponding saving in the cost of maintenance.

After the filtered sewage has been settled in these basins it will be fairly clear, but would probably contain some 30 to 40 parts per million of finely divided suspended matter. It would by no means be objectionable; the organic matter, as already stated, would be reduced so that the liquid would no longer putrefy and the nitrates would be high in amount. If this effluent were to be discharged into Back River there would be continued oxidation of the organic matter and destruction of the bacteria of the original sewage.

Owing to the small flow of upland water and the limited range of the tide, there are no strong currents in Back River, and the effluent so discharged would not, under usual conditions, reach its mouth for several weeks. We are of the opinion that there would be no danger from this discharge to the oyster beds of Chesapeake Bay, and no offense along the shores of Back River or elsewhere.

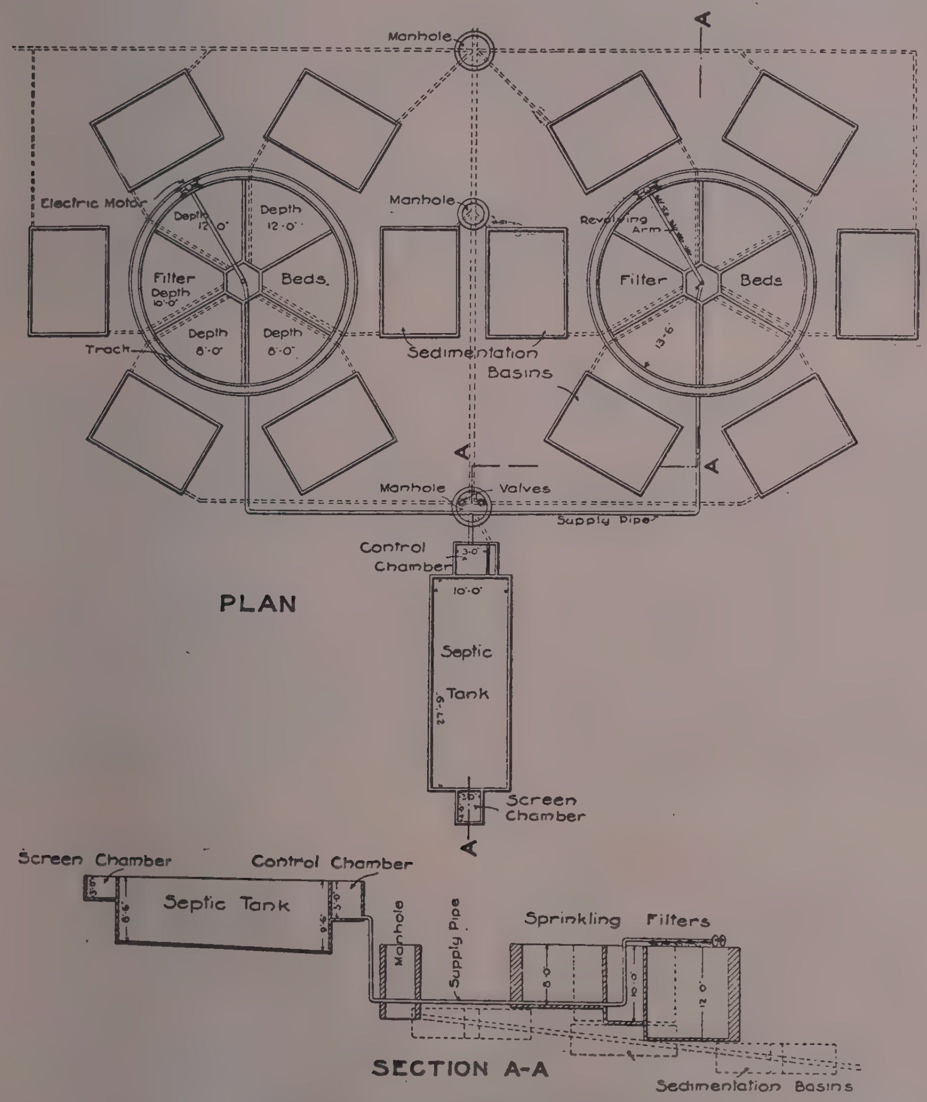
Under these circumstances the Board believes that it would be proper to discharge the effluent from these sprinkling filters, if properly managed, after holding it in the settling tanks for about three hours to deposit its suspended matter, directly into Back River.

It is also feasible to use sprinkling filters of greater depth, operated perhaps at somewhat reduced rates, to still further increase the degree of purification and bacterial removal.

Supplementary Filtration.—To remove all bacteria remaining in the settled effluent from the sprinkling filters by disinfectants, such as hypochlorite of lime or of sodium, or sulphate of copper, would be prohibitively expensive. It would be cheaper to remove the remaining impurities by subjecting the settled sprinkling filter effluent to supplementary filtration, more or less after the manner of filtering polluted water supplies.

The sprinkling filter effluent after settling may be filtered either intermittently through sand or through mechanical filters, built about like the best mill filters, but provided with certain additional appliances to facilitate their uniform and reliable operation. The Board has given detailed consideration to each of these two methods, which are substantially equal as to efficiency in removing bacteria. With our present knowledge we have thought it best to recommend intermittent filtration for the supplementary treatment.

The construction of the filter beds is substantially the same as proposed for treatment by intermittent filtration with preliminary sedimentation as before described, the underdrains, however, having much greater capacity. These beds can treat the sprinkling filter effluent at an average rate of 750,000 gal. per acre daily.



Arrangement of Proposed Testing Plant.

There will be a certain amount of suspended matter carried on to the beds, and this will gradually clog the sand surface. This deposit is of such a nature that little can be gained by raking the surface, and consequently it will be necessary to remove, wash and replace sand from the beds at shorter intervals than when filtering settled sewage. The total amount of sand so handled would be about 2.5 cu. yd. per million gallons filtered.

In estimating the cost of operating the works it has been assumed that the fullest possible advantage of machinery will be taken in order to reduce the cost of handling the sand.

In an illustration accompanying the portion of the report printed last week are shown the proposed location and arrangement of beds for a plant of 75,000,000 gal. daily and for double this capacity. In order to secure the maximum economy in construction and operation, this plan should receive further careful study, and should be thoroughly revised as to location and arrangement after a detailed and accurate survey of the proposed site has been made.

Estimates of Cost.—The estimates of cost of purifying 75,000,000 gal. of sewage daily by the sprinkling filter system of Patapsco Neck are given in Table I:

From these estimates it will appear that the probable cost of constructing the proposed purification plant as required for the next decade or until the amount of sewage exceeds an average of 75,000,000 gal. daily, will be $2,242,500, excluding supplemental intermittent filtration, and $3,283,250, including the same. In both cases the cost of land is not included, as this cost can best be determined by your commission.

The annual cost of operation, exclusive of interest and other fixed charges, is $60,500, not including supplementary filtration, and $115,500, including supplementary filtration.

Reduction in Cost of Works as a Result of Further Tests.—The Board reports that it discussed at its meetings several variations from the plan recommended, but has excluded them because it does not wish to recommend any feature of the successful operation of which, under conditions to be expected at Baltimore, it is not sufficiently assured. The Board calls to the Commission's attention some of these variations, because time will necessarily elapse before the construction of portions of the disposal works, and during this time the Commission would be able, as the result of tests made under its direction and from the experience of others, to determine that some of these variants may be adopted with resulting economy.

Chief among them is the method of supplementary treatment of the settled sprinkling effluent by mechanical filters, already referred to, which would diminish the first cost of the 75,000,000-gal. plant for supplementary treatment by from $600,000 to $700,000. On the other hand, the operation of such filters is more expensive, because of the quantity of chemicals required to coagulate the effluent before applying it to these filters. Further tests may show that the effluent can be coagulated at less cost than is now anticipated, and that this process will be cheaper after taking into account the cost of both construction and operation than the intermittent filtration process herein recommended.

Table I.

Cost of Purifying 75,000,000 Gal. of Sewage Daily.

Construction.

A. Septic Tanks, Sprinkling Filters and Settling Basins.		
Septic tanks, 25,000,000 gal. gross capacity, 10.5 ft. average depth, with inlet and outlet conduits and connections, baffles, drains, etc., complete		$200,000
Sprinkling filters, 30 acres net filtering surface, 9 ft. average depth, with foundations, drainage system, distributing conduits from septic tanks to individual filters, pipes, gates, nozzles, etc., flushing arrangements, collecting drains, controlling house, office and laboratory, electrically operated gates, etc., complete,		1,520,000
Settling basins, 11,000,000 gal. capacity, 10 ft. average depth, complete, with connections from sprinkling filters		125,000
Sludge disposal plant, including conduits, pumping stations complete for furnishing flushing and wash water, piping and reservoir, lighting plant and minor auxiliary works, complete		105,000
		$1,950,000
Supervision and contingencies, 15 per cent		292.500
Total, exclusive of land		$2,242,500
B. Supplementary Intermittent Filtration.		
Conduit from settling basins to filter beds and main distributor	:83,000	
Filter beds, 100 acres net filtering surface	742,000	
Sand washing plant and other auxiliary works	80,000	
	$905,000	
Supervision and contingencies, 15 per cent	$135,750	
		1,040,750
Total, exclusive of land		$3,283,250
II. Annual Operation.		
A. Septic Tanks, Sprinkling Filters and Settling Basins.		
Supervision, chemical and bacteriological assistants		$10,500
Attendants not included below		13,000
Disposal of sludge from septic tanks and settling basins		8,000
Average sum to be allowed each year to provide for cleaning the material in the sprinkling filters at 10-year intervals		19,000
Coal, supplies, repairs and renewals		10,000
		$60,500
B. Supplementary Intermittent Filtration.		
Care of beds, conduits and grounds, including removal, washing and replacing of sand		$55,000
Total		$115,500

In describing the design of septic tanks recommended, the Board says it followed precedent, but at its conferences the report says its members discussed the advisability of a design in which the sludge would be removed at frequent intervals from the tank, in which the suspended matters are deposited, to a separate tank in which the septicization of the sludge would take place. A small portion of the sewage would necessarily be permitted to flow through the latter tank.

The advantage of the suggested process lies in the fact that it would prevent the formation of gas in the sludge of the settling tank, which by its ebullition would lift particles of sludge toward the surface to be carried at times past the outlet of the tank and thereby tend to clog the sprinkling filters.

The disadvantage lies in the greater first cost of the tanks, the difficulties of providing a satisfactory and economical plan for removing the sludge to the separate tank at frequent intervals, and the possibility that the bacterial action required for the septicization of the sludge will not be as effective in a separate tank as in one in which the sludge is first deposited.

In regard to the size of broken stone in the sprinkling filters, there is a considerable difference in practice at different places. The use of fine stone is preferable so long as it remains unclogged, because, other things being equal, it gives a greater degree of purification. On the other hand, the use of coarser stone diminishes the tendency to clog. Before it will be necessary to purchase the broken stone, experiments can be made on the filtration of sewage through stones varying somewhat in size from those recommended which would give additional information as to the best size of stone to use for the filters.

The Board advises that tests and investigations along the lines above indicated be instituted by the Commission, believing that this will be in the interests of economy and efficiency.

Résumé and Conclusions.—To determine the best method of purifying the sewage of Baltimore in compliance with the requirements of the act under which the Sewerage Commission was organized, the Board made an extended examination of all of the usual methods of treatment.

The Board was soon able to eliminate all but three such methods; the characteristic features of one being intermittent filtration through natural sand beds, that of another being intermittent filtration through artificial sand beds, and that of the third being the sprinkling of the sewage upon beds of small broken stone.

The first method, for which sufficient areas of sandy land were found only in Anne Arundel County, was rejected because it was found that the nature of the sand, its admixture with clay, the high elevation of the land and the distance from the city were all unfavorable features, and after making outline plans and cost estimates this was clearly the most expensive of the three methods.

The Board next examined the available territory with reference to preparing artificial beds, as now used in this country and in Europe, and found several good locations for such treatment. One was situated in Anne Arundel County, near Glen Burnie and Curtis Creek, another on Patapsco Neck between North Point road and Back River. Outline plans and cost estimates indicate that the cheaper and better project was the one located on Patapsco Neck. This project was, therefore, carefully worked out and is fully described.

Finally, the Board examined the available territory for the sprinkling filter system, which method of purification has been used in Europe for eight years. This system has yielded such satisfactory results that it is now being introduced in a number of cities. It was, therefore, given a searching examination.

Two favorable locations were found in Anne Arundel County, one near Curtis Bay and the other near Swan Creek, of which the latter was studied more in detail because of some greater advantages. Two other locations were found on Patapsco Neck, one near Bear Creek and the other near Back River, of which the latter, being near a large body of water, was preferred.

Estimates of cost of the intercepting and outfall sewers and of pumping the sewage demonstrated that, as between Anne Arundel County and Patapsco Neck, by far the cheaper project was the one in the latter locality near Back River. A final comparison of the two projects having the greatest merit, and the characteristic feature of which are intermittent sand filtration for one and sprinkling filters for the other, indicates a substantial economy in favor of the latter, both in cost of construction and annual operation. For that reason it was recommended to the Commission by the Board for adoption.

Briefly stated, this system comprises first a series of reservoirs called "septic tanks," into which the sewage is discharged from the outfall sewer and remains from 6 to 8 hours, depositing therein much of its suspended matter as sludge, which gradually is reduced in quantity and made inoffensive by bacterial action, and finally is discharged on adjoining lands.

The partially clarified liquid of the septic tanks flows to the so-called "sprinkling filters." These are composed of beds of small, broken stone about 9 ft. in depth, upon which the sewage is discharged in the form of spray, from a large number of nozzles placed about 15 ft. apart at their surface. The sewage trickles or filters through the beds, a thin film of liquid surrounding each stone, and issues below freed from its putrescent matter.

This effluent then enters settling basins, where it remains about 3 hours and deposits the films of matter detached from the sprinkling filters.

The removal of the bacteria by the septic tanks, sprinkling filters and settling basins is in the neighborhood of 95 per cent. of the number contained in the original sewage.

The final process of purification is secured by discharging intermittently the effluent from the settling basins upon artificial sand filters, by which substantially all the remaining bacteria and fine suspended matter are removed, so that the final effluent is clear and has obtained "the highest practicable degree of purity."

The cost of establishing sewage disposal works to obtain this end the Board estimated as follows, excluding the cost of acquiring the necessary land: For the installation of a plant to purify 75,000,000 gal. of sewage per day, $3,283,250. For the annual cost of operating the same, exclusive of interest and other fixed charges, $115,500.

It will not be necessary to build the entire plant at once, but only so much as will be required to purify the amount of sewage delivered for a few years after works are started. The Board suggests this procedure not only for economical reasons but to obtain all possible benefit from the experience which will have become available during the first years of operation.

The Board stated it was aware of the fact that works of the type it has proposed have not yet been operated in our country on a large scale, although important experimental work has here been done. It reported that it is also aware that the works proposed at Baltimore constitute by far the largest undertaking of sewage purification in this country. However, enough plants of this type have been operated in Europe to furnish the necessary satisfactory precedents. After carefully weighing all of the evidence the Board said it is entirely satisfied that not one essential feature of the work is an experiment, that good management and operation will secure the desired results, and that these will be obtained at a less cost than with any of the older methods.

The foregoing is the report of the Advisory Board of Engineers, Messrs. Rudolph Hering, Samuel M. Gray and Frederic P. Stearns, substantially as it was presented to the Sewerage Commission, with the omission of some of the illustrations accompanying that report.

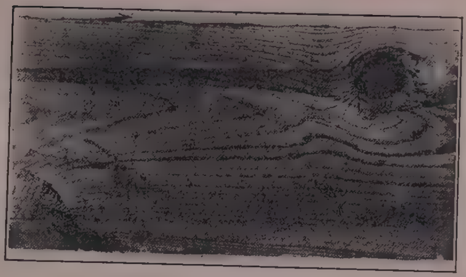
Lignite Briquets are now produced in such great quantity in Germany that the control of the fuel market is apparently about to pass from the hands of bituminous coal mine operators. The German production of lignite in 1904 was 48,500,222 tons; in 1905, it was over 52,000,000 tons and the output for the present year indicates a large increase over 1905. The greater part of this output is made into briquets, permitting the lignite to be transported readily and thus to command markets at considerable distances.

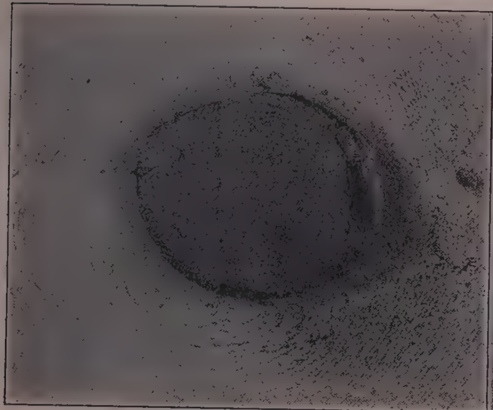
Standard Specifications for the Grading of Structural Timbers.

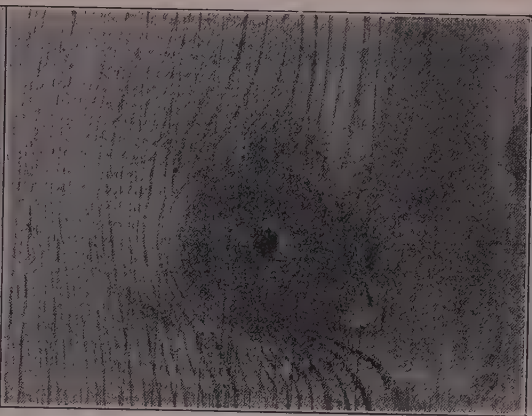
The committee of the American Society for Testing Materials on standard specifications for the grading of structural timber submitted a progress report at the recent convention of that society which takes up several features of such specifications that hitherto have been given little systematic consideration. In view of the large scope of the work intrusted to the committee the latter agreed to confine its work for the year to the collection and illustration of standard defects occurring in structural timber, with particular reference to yellow pine and Douglas fir, embodying a description of these defects and a study of the present knowledge concerning the influence these defects have on the strength of the timber. The accompanying illustrations show some of the defects that occur most frequently. The work of the committee was directed, furthermore, toward the consideration of what shall be called structural timber.

Structural Timber.—The term structural timber the committee understands to include all such products of wood in which the strength of the timber is the controlling element in their selection and use. The following list of products were recommended for consideration as structural timbers: Trestle timbers—stringers, caps, posts, mud sills, bracing, bridge ties and guard rails; car timbers—car framing, including upper framing and car sills; framing for buildings—posts, mud sills, girders, framing and joists; ship timbers—ship timbers and ship decking; cross arms for poles. It was recommended to omit for the present the following products: Railway ties, poles, piling, car flooring and mine props. The following products were not considered to come within the work of the committee: Vehicle woods, tank stock and packing box materials.

Standard Defects.—The standard defects included in the following list are mostly such as may be termed natural defects, as distinguished from defects of manufacture. The latter have usually been omitted, because the defects of manufacture are of very minor significance in the grading of structural timber: (1) A sound knot is one which is solid across its face and which is as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece. (2) A loose knot is one not firmly held in place by growth or position. (3) A pith knot is a sound knot with a pith hole not more than ¼ in. in diameter in the center. (4) An encased knot is one which is surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ of an inch in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot. (5) A rotten knot is one not as hard as the wood it is in. (6) A pin knot is a sound knot not over ½ in. in diameter. (7) A standard knot is a sound knot not over 1½ in. in diameter. (8) A large knot is a sound knot, more than 1½ in. in diameter. (9) A round knot is one which is oval or circular in form. (10) A spike knot is one sawn in a lengthwise direction; the mean or average diameter shall be considered in measuring these knots. (11) Pitch pockets are openings between the grain or the wood containing more or less pitch or bark. These shall be classified as small, standard and large pitch pockets. (a) A small pitch pocket is one not over ⅛ of an inch wide. (b) A standard pitch pocket is one not over ⅜ of an inch wide, or 3 in. in length. (c) A large pitch pocket is one over ⅜ of an inch wide, or over 3 in. in length. (12) A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fiber between grains, that is, the coarse-grained fiber, usually termed "spring wood," is not saturated with pitch, it shall not be considered a defect. (13) Wane is bark, or the lack of wood from any cause, on edges of timbers. (14) Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings. (15) Any form of decay which may be evident either as a dark red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect. The measurements which refer to the diameter of knots or holes are considered to be the mean or average diameter in all cases.


Pitch Streak.


Loose Knot.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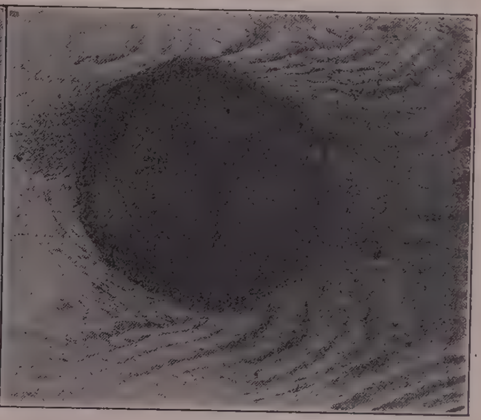
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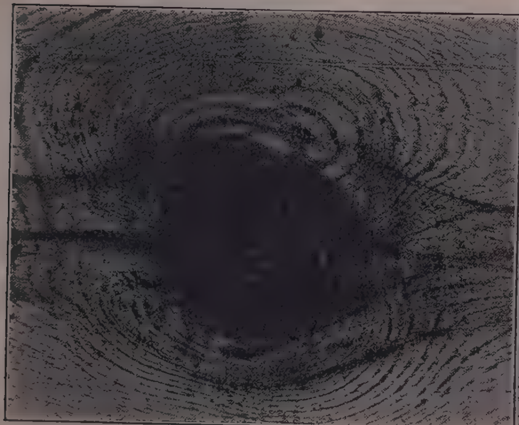
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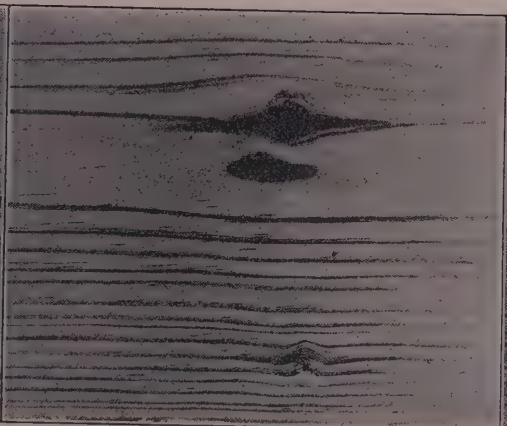
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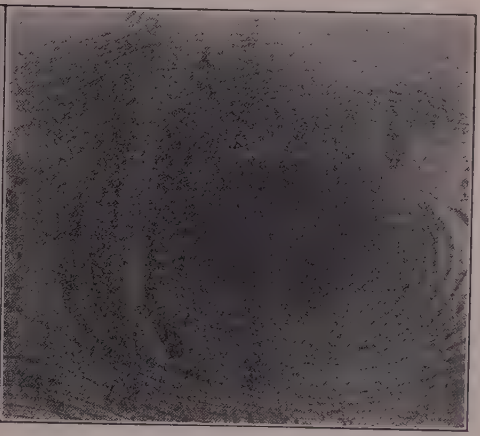
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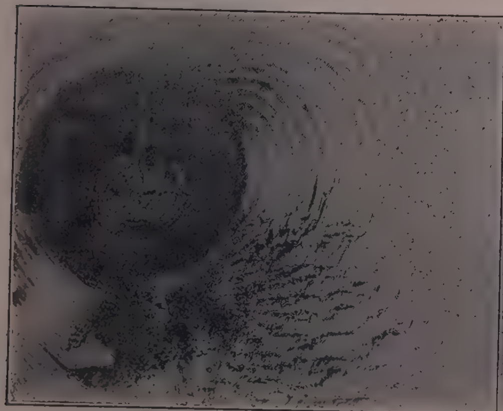
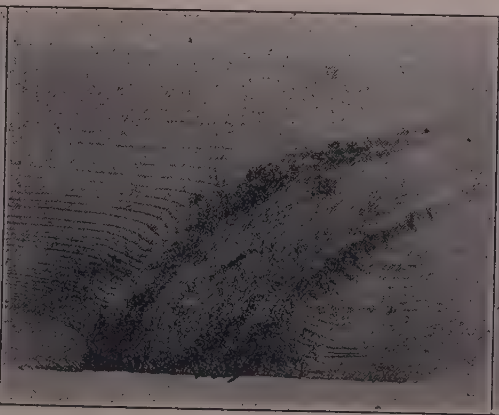
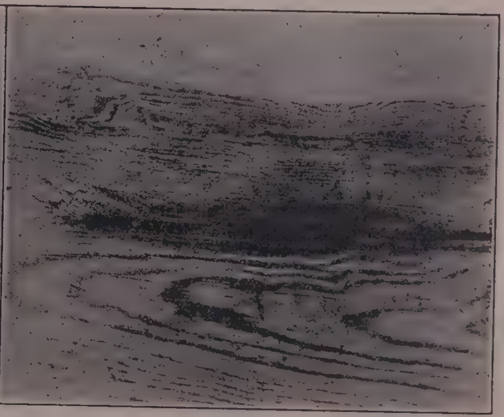

Large Knot.


Spike Knot.


Pitch Pocket.

Some Standard Defects in Structural Timbers.

Standard Names for Structural Timbers.—As indicated in the report of the committee for 1905, one of the most important matters for consideration will be the adoption of a series of common names which shall be regarded as standard for structural timbers. The rapid introduction into the Eastern States of Pacific Coast woods with names similar to those hitherto used by architects and engineers from Eastern sources has brought about much confusion. In considering this subject the committee has endeavored to select names which shall be as nearly as possible in accordance with the trade names most universally employed. Attention is called to the fact, however, that it has been the object of the committee to give distinctive names to woods which have distinctive characteristics. The term white pine may be taken as an example. White pine as ordinarily used in the lumber markets, up to within a few years, meant a soft white pine which for half a century or more came from Maine, Michigan, Wisconsin and Minnesota. White pine to the majority of manufacturers and users, of the Mississippi Valley and eastward, still means this timber. Of late years a form of pine has come from Idaho which is sold under the name white pine; and another kind of timber has come from California which is likewise sold as white pine. The three timbers are distinct forms of wood, and the same name given to all three has given rise to much confusion. The following list is presented as a preliminary one by the committee. In it are included such timbers as are believed to be structural timbers: (1) Under the name of Southern yellow pine two classes of timber are used, (a) longleaf pine, (b) shortleaf pine. It is understood that these two terms are descriptive of quality, rather than of botanical species. Thus, shortleaf pine would cover such species as are now known as North Carolina pine, loblolly pine and shortleaf pine. Longleaf pine is descriptive of quality, and if shortleaf or loblolly pine is grown under such conditions that it produces a large percentage of hard summer wood, so as to be equivalent to the wood produced by the true longleaf, it would be covered by the term longleaf pine. (2) The term Douglas fir is to cover the timber known likewise as yellow fir, red fir, Western fir, fir, Washington fir, Oregon or Puget Sound fir, Northwest and West Coast fir. (3) Norway pine is to cover what is known as red pine. (4) Hemlock is to cover Southern or Eastern hemlock; that is, hemlock from all States east of and including Minnesota. (5) Western hemlock is to cover hemlock from the Pacific Coast. (6) spruce is to cover Eastern spruce; that is, the spruce timber coming from points east of Minnesota. (7) Western spruce is to cover the spruce timber from the Pacific Coast. (8) White pine is to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota. (9) Idaho white pine is the variety of white pine from western Montana, northern Idaho and eastern Washington. (10) Western white pine, is to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as Western yellow pine, or Ponderosa pine, or California white pine. (11) Western larch is to cover the species of larch or tamarack from the Rocky Mountain and Pacific Coast regions. (12) Tamarack is to cover the timber known as tamarack or Eastern tamarack, from States east of and including Minnesota. (13) Redwood is to include the California wood usually known by that name.

A Steamer Laden With Dynamite was recently blown up in the Suez Canal after she had been sunk to drown a fire in her hold. There were three thousand 50-lb. cases of dynamite and six hundred 45-lb. cases of blasting gelatine in the hold, making a total of over 88 tons of explosive on board. The dynamite and blasting gelatine were pretty well forward. In front of and separated from them by only a wooden bulkhead was a large quantity of coke. The fire originated in this coke, and after futile attempts to extinguish it, an attempt was made to sink the forward end of the ship and drown the fire. The bulkheads gave away, however, and the dynamite was also submerged. Owing to the fear that the dynamite would exude nitroglycerine under the influence of water, it was deemed impossible to pump out the ship and refloat her, so it was decided to blow her up. In order to permit a portion of the traffic to be conducted through the canal, the latter was widened for a distance of about 1,650 ft., pending a decision as to the disposition of the ship's cargo. After the decision was made to blow up the ship provisions were carried out to reduce as much as possible the damage to property in the vicinity. Charges of explosives were then lowered into the hold in bags and connected by a cable with a point some distance away. When the electric circuit was completed a fairly narrow plume of smoke first ascended very rapidly and was followed by a more voluminous column, the top of which mushroomed out at an elevation of 3,000 to 3,300 ft. The fore part of the ship was completely destroyed by the explosion, pieces of the hull being found in a radius of 2,000 ft. According to The Engineer, very little damage was done, however, to the canal banks, or to the adjacent property, although traffic was not resumed during the day until 14 days later, and not completely resumed until nearly a month after the explosion.

An Important Decision Concerning Overhaul on Railroad Construction.

The Opinion of the Referee, Judge Alton B. Parker, to the New York State Supreme Court.

In August, 1902, defendant, the Delaware & Hudson Co., invited bids for the work of reconstructing the Chateaugay Railroad, which was at that time a narrow-gauge road from Plattsburg to Lake Placid, N. Y., connecting at the former place with defendant's railroad. From Plattsburg to Cadyville the Chateaugay road was standard-gauge, as well as narrow-gauge, a third rail having been laid. The condition was the same from Saranac Lake to Lake Placid. But between Cadyville and Saranac Lake it was narrow-gauge only. In length the road was 83 miles. It had many curves and steep grades, and when bids were invited by the company it had not determined to what extent changes would be made. Indeed, something more than a year passed after the making of the agreement with Messrs. Sundstrom & Stratton, plaintiffs, to do the work, before it was decided to make the connection at Bluff Point, known in the record as the Cliff Haven change, involving the construction of between two and three miles of new road at the eastern end. A little more than 41 miles of the reconstructed standard-gauge road was on the old road bed of the Chateaugay, the rest was new road bed. For the purpose of adapting the old road bed for the new, the curves were lessened, the banks widened and the tracks in places raised.

Upon the specifications submitted by defendant, through its chief engineer, Messrs. Sundstrom & Stratton submitted proposals, to do the work mentioned in the specifications for prices named in the proposals. Excavation, as that term was used in the specifications, covered the removal, loading, unloading, transporting and depositing of the earth; and the specifications called for a bid per cubic yard for excavation, which included transportation for a distance of 3,000 ft. Transportation beyond that the specifications treated as overhaul, and called for a bid for a price to be paid for overhaul per cubic yard per 100 ft.

Messrs. Sundstrom & Stratton bid 28 cents per cubic yard for excavation, and 1 cent per cubic yard per 100 ft. for overhaul. The date of this bid was Aug. 26, 1902. The bid was acceptable to the Delaware & Hudson Co., provided Messrs. Sundstrom & Stratton would enter into an agreement to complete the work by July 15, following, under a penalty of $100 per day for each day that the completion of the work should require beyond that date. As an inducement for the contractors to enter into this work and attempt its performance the Delaware & Hudson Co. offered to increase its bid price of 28 cents per cubic yard for excavation to 34 cents. Messrs. Sundstrom & Stratton accepted the proposition and immediately entered upon the performance of the contract. The written agreement was not in fact executed until about Jan., 1903, but as executed it bore the date of Aug. 26, 1902.

As the work progressed, monthly estimates were made by the defendant's engineer, and payments made thereon until the work was finally completed, and the contractors had withdrawn from the road, at which time, according to the claim of defendant, it was indebted to plaintiffs in the sum of $124,846.38. On the other hand, plaintiffs claim that defendant was indebted to them in the sum of $1,929,271.74.

The complaint alleges eight causes of action, and upon the trial defendant made admissions as to the amount due upon the several causes of action, from the second to the eighth, inclusive, which were acceptable to plaintiffs, and in accordance with their claim. And defendant also made such admissions as established a concededly unpaid balance upon the first cause of action, of $106,786.28.

This eliminates all the features of the controversy between the parties as disclosed by the pleadings, except two: First, for overhaul, plaintiffs claim they are entitled to the sum of $1,794,976.75, under the contract, less the sum of $52,530.60, which sum has been allowed to them by the defendant as overhaul, leaving a balance of $1,742,446.15; second, as to the classification of the excavation.

Plaintiffs claim that the 1,719,306 cu. yd. properly classified, gives 1,203,514.21 cu. yd. of earth, 429,826.51 cu. yd. of loose rock, 85,965.31 cu. yd. of solid rock, which, at the contract price would amount to $765,950.83. Defendant agrees with plaintiffs that the number of yards of excavation is 1,719,306, but claims that they have been properly classified by the engineer, and that as classified there are 1,608,663 cu. yd. of earth, 87,922 cu. yd. of loose rock, and 22,721 cu. yd. of solid rock; and that at the contract prices plaintiffs were entitled to $627,111.92 for excavation—a difference of $138,838.91.

I shall first consider the subject of overhaul, and, for convenience, shall divide it into two periods, for reasons that will later appeal, namely: First, the period from the beginning of the work, to July 15, 1903, that being the date at which the contract was to be completed; second, the period succeeding July 15, 1903.

There is no dispute about the number of cubic yards hauled more than 3,000 ft. Nor is there any dispute as to the number of feet such cubic yards of excavation were hauled. So, if it be true that plaintiffs are entitled under the contract to overhaul for every cubic yard of earth transported more than 3,000 ft., at the rate of 1 cent per 100 ft., then there is due plaintiffs the full amount which they claim as overhaul down to July 15, 1903. And there is no opportunity for controversy about it, because the facts, in so far as they relate to the number of yards of overhaul and the distance of the haul, are undisputed.

Defendant, however, insisted upon the trial, and still insists, that plaintiffs are only entitled to recover overhaul for such portion of the excavation as was hauled in narrow-gauge cars, and inasmuch as the larger portion of the overhaul was made in standard-gauge cars, there must be a deduction from plaintiffs' claim in that amount. And defendant insists that, by reason of that fact, there is nothing due plaintiffs for overhaul prior to July 15, 1903, because, by its chief engineer, it has made allowance for all overhaul in narrow-gauge cars.

We must, therefore, turn to the contract to see what was the agreement of the parties on this subject. The formal parts of the contract are very brief. Just enough to incorporate within it the specifications upon which the defendant company solicited the bids of contractors, together with the proposal of the favored contractors, Messrs. Sundstrom & Stratton, by which, in detail, the plaintiffs stated the prices at which they would do the several items of work enumerated in the specifications. The written agreement provided that the contractors would do the work called for by the specifications, under the supervision and to the satisfaction of the engineer of the company, "in accordance with the specifications hereto annexed, which are hereby made a part of this contract, in the way and for the amounts for the different classes of work stated in the proposal sheet of the contractors hereto annexed, which is also made a part of this contract; and to complete said work over the entire line above stated to the satisfaction of the engineer of the company, on or before July 15, 1903."

It further provided that, "the company, in consideration of the premises, hereby agrees to pay the contractors the amount stated in said proposal sheet for said work, in monthly payments, on monthly estimates made by the engineer of the company, as the work progresses, less 10 per cent. of said monthly estimates, and to pay the full amount for said work in accordance with said proposal sheet at the completion thereof to the satisfaction of the engineer of the company."

The contract also provided for a forfeit of $100 per day for each day's delay, after July 15, 1903, in the completion of the work by the contractors, and called for a bond by the contractors for faithful performance.

Turning to the specifications, which are incorporated into the contract and made a part of it, we find the subject of excavation considered under subdivision 13. It declares that "excavation will include the removal and placing on embankments (as hereafter described) of all classes of material necessary for the formation of the roadbed of all main and side tracks."

How excavation is to be paid for is provided in subdivision 19 of the specifications, under the heading, "Overhaul," which reads: "The price paid for excavation in all of the several classes thereof will be understood to cover and pay for the entire expense of its removal, by any method whatever, including loading unloading, transporting and depositing in the manner described in the specifications, in the places designated by the engineer; provided, the extreme haul of the material so transported does not exceed 3,000 ft., and beyond that distance the price named in the contract per cubic yard per 100 ft. will be allowed and paid for such overhaul."

The specifications, therefore, called for a bid for a fixed sum per cubic yard to be paid for excavation, which should include its removal from bank or cut, its loading, unloading, transporting and depositing, provided the extreme haul of the material should not exceed 3,000 ft.; and the specifications, in effect, further called for a bid for prices to be charged per cubic yard for each 100 ft. that any portion of the excavation should be hauled beyond the 3,000 ft.

In answer to these specifications, Messrs. Sundstrom & Stratton submitted bids, and their bids were entitled, "Proposal," and they are so designated in the contract. In this proposal Messrs. Sundstrom & Stratton named the price for doing each and every of the things called for by the specifications. On the subject of overhaul, the proposal reads: "Overhaul per cubic yard per 100 ft. as per specifications, 1 cent."

As the proposal of Messrs. Sundstrom & Stratton, and the specifications of the Delaware & Hudson Co. were each made a part of the contract, it necessarily follows that the contract provides that 34 cents per cubic yard shall be paid for excavation, covering removing by any method whatever, including loading, unloading, transporting and depositing in the place designated by the engineer, unless the extreme haul of the material so transported exceeds 3,000 ft., in which event 1 cent per cubic yard per 100 ft will be allowed and paid for such overhaul.

There does not seem to be any ambiguity about this feature of the contract. The price paid for excavation by clear and precise terms is made to include loading, unloading, transporting and depositing "by any method whatever," and hence, for the excavation so loaded, unloaded and transported more than 3,000 ft. "by any method whatever," whether wheelbarrow or cart, narrow-gauge or standard-gauge cars, the company will pay 1 cent per cubic yard per 100 ft. Such, certainly, is the letter of the contract, and within its four corners there is not to be found a single sentence or phrase suggesting that the parties had in mind any exception to the broad and comprehensive phrase, "by any method whatever." And of course the rights of these parties must be measured out by the terms of their written contract, unless, of course, subsequent to its execution, the parties to it agreed upon modification. It is not pretended that they did modify it during the period it provided that the work should be completed. Indeed, it is conceded that they did not.

Whether the contract was more favorable to plaintiffs than it ought to have been, in respect to the matter of overhaul; whether the defendant or its officers, or its engineer, had in mind, in agreeing to accept plaintiff's bid on the subject of overhaul, that the dirt would all have to be hauled in narrow-gauge cars, is of no importance in determining the rights of the parties under this contract. The written agreement is, in law, the repository of the real agreement of the parties. All prior engagements are deemed to be merged into it. And hence it follows that the evidence introduced tending to show that the representatives of the defendant at least expected only to pay for material hauled in narrow-gauge cars, can have no weight in the direction of giving to this contract a construction other than that which its language clearly and precisely imports. And it imports, as it seems to me, plainly and distinctly, that all material hauled over 3,000 ft. by direction of the engineer in charge, is to be paid for as overhaul, no matter how it may be hauled, whether in narrow-gauge or standard-gauge cars.

It is urged, on behalf of defendant, that the parties themselves, during the execution of the contract, placed a construction upon it which is hostile to the language of the written contract, and that this construction should be accepted by the court.

One answer to that contention—and a sufficient answer, in my judgment—is that the parties to the contract never modified it, during the time in which plaintiffs agreed to perform it, or agreed upon a settlement of their differences under it, or did any other act that would estop either of them from demanding at the hands of the court a determination of their respective rights and claims, according to the terms of the written contract. If the agreement were indefinite or ambiguous as to the overhaul, the court should inquire as to the acts of the parties for the purpose of ascertaining whether, in carrying it out, they did place a definite construction upon it. The acts of parties in such situations are helpful. The written contract is the repository of the intention of the parties. If that intention is not, however, made clear by the terms of the contract, their conduct under it may be resorted to for the purpose of determining what their intention was when causing their agreement to be reduced to writing. But, as I read this contract, there is no opportunity to hold that it is ambiguous, and hence no occasion to examine into the conduct of the parties to see whether they construed it otherwise than its plain terms required.

Were such an examination to be made, however, it would not be possible to find that plaintiffs admitted from the outset that they were entitled to the overhaul in narrow-gauge cars only.

Mr. Sadler's (the engineer in charge of the work for the defendant) testimony shows that in the early stage of the work Mr. Sundstrom was protesting so frequently on the subject of overhaul, as to be annoying. Indeed, it was his protest to Sadler in June, at which time he insisted that he was entitled to overhaul, whether in narrow or standard-gauge cars, that led defendant's chief engineer to have a conversation with Mr. Sundstrom, and in the presence of Mr. Sadler, on July 15, 1903, to which reference will be made later.

In the light of these protests, therefore, I repeat that, were it material, it would be impossible, it seems to me, to find that the conduct of the parties indicated that both understood at the time of the making of the agreement, that it entitled the contractors to overhaul only when the earth should be hauled in narrow-gauge cars.

The record does not satisfactorily explain how it happened that Messrs. Sundstrom & Stratton, after the completion of their work, tried to procure the payment of the balance due them according to the monthly estimates, without at the same time making a demand for the overhaul. That they were pressed by their creditors quite sufficiently appears, and it may have led them to get all the ready cash they could before presenting their claim for overhaul, which was a very large amount. But let the motive be what it may—whether the suggestion I have made furnishes the explanation, or there is no reasonable explanation—the fact remains as I view it, that it was utterly immaterial whether their conduct indicated that plaintiffs' understanding was that they could not recover overhaul, or that they were doubtful about it, or even that they had been advised that they could not recover, for they may recover, because the contract says so.

If the contract were ambiguous, the testimony to be found throughout this record, which, in part, has inspired the suggestion just made, would be entitled to consideration, in obedience to the rule requiring the court in such cases to take into consideration all the facts and circumstances surrounding the making and execution of the contract. But there is no ambiguity, as I read the contract, but instead, it is clear, precise and definite in so far as it relates to the subject of overhaul and the price to be paid for it.

Testimony was given on the part of defendant tending to show that in December, 1902, there was a conversation between defendant's chief engineer, Mr. MacMartin, and Mr. Sundstrom, on the subject of overhaul, in the course of which Mr. MacMartin insisted that plaintiffs should not have overhaul in standard-gauge cars. Several witnesses testified upon that subject, and they are not in agreement as to the point of it. But I shall not attempt to find precisely what was said between the parties, for, as I view it, it can have no bearing upon the question whether plaintiffs are entitled to recover for overhaul carried in standard-gauge cars as well as narrow-gauge cars, prior to July 15, 1903.

It will not be pretended that this evidence accomplishes a modification of the contract, because at that time the contract had not been executed. The contract bears date of Aug. 26, 1902, but it was not, in fact, executed by the parties until about Jan., 1903, sometime subsequent to this conversation. All prior negotiations, understandings and agreements of the parties will be presumed to be embodied in the written instrument, not only at its date, but as late as the date of its execution.

Had the evidence been offered for the purpose of modifying the contract, it should have been excluded. But it was not offered for that purpose. Indeed, it was admitted by defendant's counsel that the contract was not modified.

If it were not the rule of law, as I have asserted, that all prior negotiations are deemed to be merged in the written instrument down to the time of its execution, whether that be later than the date of the contract or not, adopting the view of the testimony most favorable to the defendant, it would not be held that there was a modification of the contract in respect to the overhaul. The version of the conversation as given by defendant's witnesses does not pretend that Mr. MacMartin was attempting to bring about a modification of the contract. And further than that, counsel concedes upon the record that there was no modification of the contract during the life provided by its terms, in respect to overhaul. It is further contended by defendant that the monthly estimates delivered to and accepted by plaintiffs constituted an account stated, by which plaintiffs are concluded.

It is not quite true that plaintiffs accepted all of these monthly estimates without protest, for Mr. Sadler, the engineer responsible for the estimates, makes it clear that protests were occasionally made to him. But if it were true that there was no protest, it could not be held in this case that these monthly estimates when paid constituted an account stated between the parties, for the contract provides otherwise. Unquestionably the doctrine of an account stated, which grew out of the custom of merchants, has in recent years been so extended as to cover a wide variety of business transactions. But in every one of them it will be found that there was opportunity for the finding that it was clearly the intention of the party compiling and rendering the account to make a definite and final statement of the transactions between himself and the other party down to the time of its rendition, for the purpose of obtaining a final settlement of affairs at that time. But neither this defendant nor its officers could have had any such intention in making out the monthly estimates, and if they had such an intention it was without force, because the contract, in terms, provided that the monthly statement should contain an estimate merely of quantities, an estimate made by the engineer as a basis upon which to make payment to the contractor from time to time as the work progressed. And it further provided that, in addition to the making of the monthly estimates, and the payment of the amount estimated to be due, less 10 per cent., that the defendant should "pay the full amount for said work in accordance with the said proposal sheet at the completion thereof, to the satisfaction of the engineer of the company."

It mattered not, therefore, whether the defendant's engineer estimated the amount of work during a given month at too much or too little. At the completion of the entire work the contract provided for compensation for the full amount of work, in accordance with the proposal sheet. The parties bound themselves by the terms of their contract to pay for the full amount of the work according to the proposal, when the contract was completed, and it was not within the power of one of them acting alone to change it. And of course it goes without saying that the right to full payment for all the work done in accordance with the proposal, could only be cut off by modifying the contract.

My conclusion is that the contract, on the subject of overhaul, is unambiguous, and that it clearly provides, in subdivision 19, for the payment of overhaul, whatever the method employed; that its terms were broad enough to include every method of hauling, whether by standard-gauge cars, narrow-gauge cars, or otherwise; and hence, that there is embraced within it all the overhaul prior to July 15, 1903, for which plaintiffs claim.

It follows, if the views expressed be sound, that plaintiffs are entitled for overhaul under their contract up to July 15, 1903, in the sum of $717,218.92.

We come now to the claim for overhaul, covering the period subsequent to the completion of the laying of the standard-gauge track, which took place shortly after July 15, 1903, the line being connected throughout on August 2.

By the contract plaintiffs were not required to do all the work of building the road and putting down ties and laying the tracks. Instead, the work which they were required to do, was to bring the roadbed to sub-grade; and they agreed to build the roadbed, including slopes, so that they should be "constructed in accordance with the plans attached, or in accordance with such modifications thereof as the engineer may from time to time direct." From this provision it will be seen that it was the scheme of the specifications that plaintiffs should do the work in accordance with the plans attached to the contract, which involved bringing the roadbed to sub-grade, unless the engineer of defendant should modify the plans, in which event the plans as modified, rather than the original plans, came within the contract. In other words, the plans were to govern in the absence of any modification thereof by the engineer, but the right of the engineer to make changes in the plans was expressly provided for.

Now the contract distinctly provided that the work to be done by the contractors, in accordance with such plans, as subsequently modified by the engineer, should be fully performed by July 15, 1903. In case of default the plaintiffs agreed to forfeit $100 per day. To induce plaintiffs to make this agreement and to perform it, defendant voluntarily raised its bid of 28 cents per cubic yard for excavation, to 34 cents. And in the disposition of this case it is my duty to assume, that the plans as modified by the engineer were so far completed as that defendant had the right under its terms to declare full performance on the part of plaintiffs, and dismiss them from the work. Plaintiffs claim to have so far made performance by July 15, 1903, that they could not be subjected to the payment of $100 per day for any time in addition thereto that they stayed upon the work; and defendant concedes that to be true.

There was, however, work still to be done by some one, in order to ballast and otherwise improve the roadbed. The situation then was one which permitted the defendant either to do the work itself, to contract with some one else to do it, or to allow plaintiffs to excavate and haul the earth for it to put under the ties. The question, then, which defendant's engineer had to face about the middle of July, 1903, was whether the contractors should be allowed to do this work, or whether the company should do it, or contract with someone else to do it.

The point had been reached for which defendant was straining at the time of the letting of the contract in 1902; the standard-gauge road was then about completed, and trains could be run over it to take care of the summer traffic. That point reached, the pressure upon defendant company was relaxed. What remained to be done could be done more leisurely, and it was. The question whether plaintiffs should be allowed to do the work, or some other provision made for the doing of it, was a pressing one, however, from the viewpoint of Mr. MacMartin, chief engineer, because of the report made to him by Mr. Sadler, the engineer in charge of the work.

The latter had a conversation with Mr. Sundstrom on the subject of overhaul sometime in June, 1903, in which Sundstrom insisted that he should have overhaul on the entire work, and this conversation Mr. Sadler brought to Mr. MacMartin's attention. So, on July 15, 1903, Mr. MacMartin had a conversation with Mr. Sundstrom, in the presence of Mr. Sadler, in which, according to Mr. Sadler, the engineer said that there was to be no compensation for overhaul in standard-gauge cars, the laying of the tracks for which was then nearly completed, and that if Mr. Sundstrom was not satisfied with that he would take the work out of his hands and do it himself, or the company would do it. That he would make one exception, namely: from Onchiota out on the marsh, and that material would be taken from the nearest cut. To this Mr. Sundstrom made no reply in words, but bowed his head. He further testified that subsequently the resident engineer on the Onchiota cut marked out a stake as a limit of haul, beyond which overhaul would not be allowed, and called the attention of Mr. Lahan, the foreman of the plaintiffs, to it. Overhaul for the work thus done was in due course allowed by defendant.

Mr. MacMartin testified that on July 15, he said to Mr. Sundstrom, in the presence of Sadler, "I had a verbal arrangement with you that you were to receive no overhaul for material hauled in standard-gauge cars. Now I want it understood distinctly that you are not to have any such overhaul. If you are not satisfied with that arrangement, take your steam shovels off the road. We will put ours in and do this work from the borrow-pit. . . . Mr. Sundstrom then said, 'What becomes of the overhaul of the material I am hauling near Chazy Lake—that, if you hadn't changed the gauge last winter, would have been done in narrow-gauge cars, and I would have been entitled to overhaul." I replied that he would get the overhaul from the nearest cut to the fills, as if he had done it in narrow-gauge cars. He then said, 'What about the overhaul along the Bloomingdale marsh, that I would have been entitled to had it been done before the gauge was changed?' I said, you will be paid for that overhaul as though the material was taken from the nearest cut to the fill into which it is put. . . . The engineers will set stakes indicating to your men from what point you will be paid overhaul. Mr. Sundstrom replied, as near as I can remember, 'That's all right; that settles it.'"

September 3, 1903, Mr. MacMartin wrote a letter to Mr. Sundstrom, which, so far as material, is as follows: "Regarding the material that is to be taken from the cut at Onchiota on the Chateaugay Railroad, with standard-gauge equipment, for the purpose of widening out the banks and raising the sags between there and Bloomingdale, I wish to advise you that no overhaul will be paid on this material, excepting that which would be necessary providing the borrow pits were located at the nearest point to the fill to be made. While I had a verbal understanding with you to this effect, I wish same confirmed in writing before the work with standard-gauge equipment is started."

While there is other evidence upon this subject, I find that the conversation between the parties was as given by Mr. MacMartin, and that Mr. Sundstrom acquiesced in the proposition of Mr. MacMartin, which was in effect that Messrs. Sundstrom & Stratton should leave the work unless they were willing to haul such further earth as should be needed for ballast and other purposes, on the standard-gauge tracks, at the rates provided for excavation, with the exception of the two places, and as to those places, they were to have overhaul from the borrow pit nearest to the place of deposit. And that the defendant was in a position to insist upon it, because the time within which the contract was to be completed had run, and the roadbed had been brought to sub-grade, according to the plans as modified by the engineer.

But for their acquiescence the plaintiffs would not have been allowed to do any work after the expiration of the period within which they had agreed to complete the work, and within which the standard-gauge tracks were nearly all laid, the last work in that regard being finished on August 2. They would not have been allowed to haul further excavation, because it was for the engineer to say, under the contract, what should be taken and accepted as sub-grade; whether the embankment had been brought up to the plans or below. Modifications of the height of the sub-grade, or the width of the embankment, were within the engineer's right under the contract. Whatever he was satisfied with in that respect was within the contract, according to the terms of it. And, while it is of no legal consequence whether the engineer's course was in part induced by the fact that otherwise the contractors would receive much more for the work than it was fairly worth, the fact is that the position taken by him on July 15 was not inequitable.

The defendant accepted the proposal of the plaintiffs without question, and raised the proposal covering the more important feature—the excavation—more than 20 per cent., as an inducement to expedition by the contractors in doing the work, and upon their agreement to complete the work by July 15, 1903. The summer passenger traffic of the Chateaugay road constituted a very important part of the year's business, and it was deemed wise to pay extra for haste, in order to save that business for the year 1903. It was with that object in view that the substantial and generous raise in plaintiffs' bid was made. The time for the completion of the work having arrived, and the chief engineer having decided to accept the work done as a performance of the contract, it was not inequitable to make new terms upon which plaintiffs should perform work, much of which was not even contemplated by the original contract. By its terms, as I have observed, plaintiffs were only to bring the roadbed to subgrade. Now ballast was to be hauled. This defendant could do, or hire others to do, but, as plaintiffs were on the ground with their steam shovels, cars and tools, the engineer representing defendant, in effect, notified plaintiffs that they should take their implements out unless they preferred to do such further work as the engineer decided to have done, at the rates provided in the contract, less overhaul, except in the two instances heretofore referred to. Plaintiffs accepted this proposition, performed all subsequent work under it, and are bound by it.

It follows that the claim for overhaul subsequent to the date of this new agreement amounting to $1,077,757.83, should not be allowed.

Plaintiffs contend that the total excavation of 1,719,306 cu. yd. was not properly classified, the importance of the classification being due to the fact that the contract authorized plaintiffs to receive 34 cents per cu. yd. for earth excavation, 55 cents for loose rock and $1.40 for solid rock. They have attempted to show that of the total excavation over 85,000 cu. yd. was of solid rock, whereas they were allowed less than 23,000; and that of loose rock the cubic yards excavated exceeded 429,000, whereas they were only allowed less than 88,000.

Defendant insisted upon the trial, and still does, that the classification by the engineer is final and conclusive upon both parties, and therefore can only be attacked for fraud. While there are cases in which that authority is conferred upon an engineer or architect, and although when it is so conferred it will, save in exceptional cases, control, such cases are without influence in this one. The reason is that no authority by this contract was conferred upon the engineer to determine the classification. There is not a suggestion anywhere in the contract that he should be the final arbiter between these parties as to any difference arising about the classification of the excavation. What he did was proper for the purpose of making the estimate upon which to base a monthly payment; but, at the conclusion of the work, by the very terms of the contract, plaintiffs became entitled to recover for all work done.

The question now up for consideration, therefore, is, whether plaintiffs have established by a fair preponderance of evidence, that the amount of solid and loose rock removed in the course of the excavation was as claimed by them. In my judgment they have not. They have produced some competent and skilled engineers, who went over the ground months after it was completed, and rather hastily, it seems to me. And upon that inspection they have made an estimate of the amount of loose and solid rock excavated. While I have no doubt of their ability, nor of their intention to present the situation fairly to the court, the fact is not to be lost sight of that there is presented in opposition to their opinions, on the question of quantity, the opinions of other experts introduced by defendant. And in addition to that their opinions are confronted by the testimony of resident engineers covering the work in great part, who testified as to the methods adopted by them in ascertaining the quantities of rock. What they say they did in order to ascertain the quantities as the work progressed is fairly illustrated by the testimony of Mr. Nash, a resident engineer, in response to the question: "In what way was the quantity of loose rock ascertained?" His reply was: "Well, the boulders of any size were measured. I measured a great many myself. I had two transit men both authorized to measure boulders. I had a timekeeper authorized to do the same thing. The entire party assisted me in that respect. The bulk of the loose rock on the work done after I took charge was small, and it was estimated on a percentage basis by measurements and frequent observations."

It does seem that a resident engineer, charged with the duty of ascertaining the amount of rock is, by the method testified to by Mr. Nash, better able to ascertain the quantity of rock than another engineer who spends two or three days on the road after the work is all done. These resident engineers—and together they cover the entire line of the road—made monthly reports to Mr. Sadler, the assistant engineer. The resident engineers who were produced as witnesses gave every appearance of being men of character, and there was nothing in their cross-examination which tended to throw discredit upon them.

It was also the business of Mr. Sadler, the assistant engineer, whose office is located at Plattsburg, to go over the road frequently and make observations which should guide him in considering the reports made to him by the resident engineers on the subject of excavation. For it was his duty to make an estimate upon which the payment for the month should be based. He certainly had a very great advantage, as it seems to me, over the engineers produced, either by plaintiffs or defendant, as experts, in determining a proper classification. And I am led to believe, after considering his demeanor on the stand, and carefully weighing his testimony, that he intended to make a proper classification, and further, that he believed that he had done so.

Mr. MacMartin, the chief engineer, and the three expert engineers produced by defendant, gave it as their opinion that the classification as a whole was liberal toward the plaintiffs. I, however, attach more importance to the testimony of the resident engineers and the assistant engineer, because it was their business to ascertain the quantities of solid and loose rock, and they had the opportunity of actual measurement and daily inspection, which they say they took advantage of; and the close of the case finds their reputations as free from criticism as that of the expert witnesses.

My conclusion, therefore, is that plaintiffs have not established the classification to be as claimed by them, and that the classification as claimed by defendant must stand.

The amount of payment awarded to the plaintiffs amounted to $951,000, together with interest and costs, amounting to about $1,135,000 in all. The plaintiffs are also at liberty to secure payment on the basis of the contact for overhaul on work done after July 15, 1903. The plaintiffs were represented during the proceedings by the following engineers: Messrs. Wm. R. Hill, John G. Tait, John W. Burke, George W. Lee and H. B. Reid; and by Mr. Thos. Watts as attorney. Mr. Lewis E. Carr was the attorney for the defendant.

Damming the Mississippi River.

Damming the Mississippi River at the Des Moines rapids, just above Keokuk, Ia., is now being seriously considered again after having been abandoned several years ago as impracticable by the last company which investigated the feasibility of the project. A Canadian syndicate, with Mr. C. P. Cooper as chief engineer, has for nearly a year been making detailed investigations to determine the most suitable site for a dam, compiling statistics concerning the flow of the river and considering in detail other features governing the location and construction of such a dam. Although none of these investigations have been made public, it is generally understood that a suitable site for a dam has been located and that the project is considered feasible. Several field parties have recently started complete surveys on both sides of the river above the rapids to determine just how much land would be submerged by the proposed dam, and while it is said that much larger areas will be flooded than was anticipated, there is little probability that the value of the submerged lands will alone be great enough to render the project impracticable. The greatest difficulty to be overcome in the construction will undoubtedly be the control of the tremendous flow of the river during high water. If it is considered that the building of a dam across the river at the site chosen is possible at a reasonable cost, there is apparently no reason why it will interefere with navigation sufficiently to warrant any serious objection to it being built. The canal and locks on the Iowa side of the river at the Des Moines rapids which were built many years ago by the Government, are already used by practically all of the boats plying up and down the stream, as the current over the rapids is so swift as to render navigation through the latter difficult and hazardous, except during high water. As far as a profitable disposition of the power that could be developed by a dam at these rapids is concerned, there seems to be little doubt, since a number of cities of considerable size could be reached by electrical transmission lines of reasonable length and, furthermore, the country in the immediate vicinity is fully developed.

Letters to the Editor.

Damp Resisting Paint.

Sir: The prime requirement of a damp resisting paint must be its permanency, that is, the quality to remain a continuous adhesive film impervious to air and moisture. Under this condition it will protect any substances over which it is properly applied, from these elements, even though they may be charged with foreign agents tending to destroy them.

Acids or alkalis may be present in either element, causing corrosion or disintegration. These must be repelled, and the film of paint, protecting under these conditions, must remain inert to the changes of temperature. It is apparent that a paint possessing these qualities must yield the expected results, provided its faithful application can be guaranteed. This element alone has condemned many erstwhile good materials.

The original quality of every grade of material, within a certain sphere of application, has been learned by the paint manufacturer through his experiences, and they in turn must be urged on the purchaser, who must choose with scrutiny that grade of material best suited for a specific purpose.

The application depends on the fidelity of the mechanics using the paint; this is the human element and the most fallible. The moment we deal with these agents too much care cannot be exercised in making them understand the correct manner of executing the work so as to come as near as practicable to the laboratory standard. Failure to do this on the part of the consumer will measure the degree of his impression as to the quality of the paint, and if done for the purpose of economy the difference in the standard of work produced will be measurable by the dollars and cents in his pocket. In both cases, however, this consumer is the enemy of the manufacturer.

Brushing in paint is the best method to insure a uniform coat; the proper penetration into the pores of the material coated; the close examination of the surface covered and its thorough preparation (which is often more important than the application of the paint) and finally it will give the best results eliminating to the greatest extent the presence of air bubbles.

With these facts in view, a damp resisting paint with the qualities before mentioned, when applied over a continuous surface capable of retaining its film condition after application, impervious to air or moisture, insoluble, having great adhesive properties, being inert to the atmospheric changes, will be capable of resisting injurious agents in moisture or air whether conveyed to it by capillary force or contact.

A film or paint of any description used for the protection of materials cannot resist against abrasion, therefore, the purpose for which it is desired would determine whether the film should become hard after application, or should remain soft; but in neither case to never become brittle or lose is elasticity and original toughness nor impair its adhesion.

The capacity of damp resisting paint to remain permanent when incorporated between two substances, as a cementing medium and impervious film, has been proved by actual use for a period of eight years. Beyond this, I claim I am unable to state from my own experience. During this experience I have used very large quantities of damp-resisting paint for various purposes, as hereafter stated, and with uniform success. Various methods have been used for the different purposes which are as follows:

Using a heavy coat thick compound and sprinkling with ground cork forming a mat for insulating exposed steel work from condemning moisture in the atmosphere; hence, protecting the ornamental work below it from rust stains as well as water. This work was done in space between roof beams and false work plaster ceiling below them. The compound used remains permanently soft and adhesive.

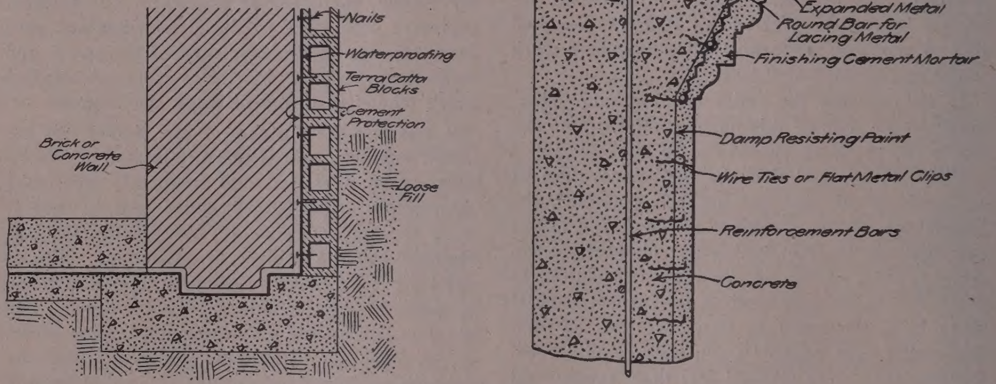
Using decorative paint colors on exposed interior iron work. The damp resistant acted as a protective coating to the iron as well as forming a rust proof base under the decorative colors. The compound dries sufficiently to become tough but not brittle.

Using one or two coats of damp resisting paint on the interior of stone, brick, cement and terra cotta walls for damp-proofing. These walls being at various times after the application of the compound coated with plastic substances for a finish coat, applied right on the paint, such as lime mortar gauged with slight amount of Portland cement, ordinary lime mortars, ordinary plaster mortars and patented plaster coatings, all of which were applied directly over the paint with a trowel in the usual methods. The compound used remains semi-soft and permanently adhesive between the two substances. A distinct advantage in this is due to the fact that when the plastic substance is applied to porous substances the film intercepts the moisture in the plaster, thereby preventing it from being absorbed into the substance, and hence causes the plaster to dry entirely through its own body. In all instances, this prevents staining and too quick drying and is beneficial to the plaster.

Using one or two coats of the damp-resisting paint on the inside of exterior walls and applying directly to it cement scratch coat mortar gauged with lime putty, and then applying to this regular enameled tiles. This forms an excellent adhesive bond and prevents the moisture from penetrating to the tiles. The compound used remains permanent the same as that used under the plastic coatings.

Using damp resisting paint one or two coats as a finishing color on exterior structural steel work exposed. The compound used dries sufficiently hard to resist all ordinary conditions of exposure; it never becomes brittle. Under this condition proper maintenance is absolutely necessary and especially where abrasions have occured. This compound is superior to all oil paints or varnish paints, as it effectually resists the action of sulphur gases.

Using damp-resisting paint on steel construction which is encased in masonry and fireproofing substances. A thorough field coat being applied and carefully maintained as the work progresses in advance of the covering. The masonry and fireproofing over the steel should be well cemented on so that every portion of the steel construction is embedded within it. Corrosion from air and moisture can at no time set in, as the film of paint covered with cement will positively protect the steel. The compound used dries semi-hard and remains permanent in that state. It is very tough and adheres to the cement as well as to the steel. Linseed oil paints are useless when in contact with cement, because they form lime soaps and are not alkali proof.



Method of Applying Damp Resisting Paints.

In the use of damp resisting paint for the protection of structural steel both exposed and covered, I have had considerable experience with red lead shop coat and damp resisting paint field coat. A thorough job being made with each coat, especially with reference to unseen parts (assembling) and connections on field work (erecting). This work should be done by journeymen painters only.

During the last two years I have had under close observation the use of a cement paint, a synthetic compound of Portland cement and a binder, applied as a shop coat and then protected with a field coat of damp resisting paint. This should prove the very best method of protecting steel, as the protective qualities of Portland cement to raw steel is an established fact and adding to this a film paint impervious to air and moisture it should prove an absolutely permanent protection.

I cannot give any reasons to recommend the use of protective paints on steel bars, etc., used in concrete canstruction because of the protection afforded them naturally by the cement in the concrete; excepting, however, to state that they should not be too close to exposed surfaces, and that sub-structures should be absolutely damp-proofed or waterproofed on the exterior, as the case may be, according to the condition of the ground upon which they stand.

Concrete walls exposed to the atmosphere, especially in moist climates, act in the same manner with reference to the moisture as masonry walls of any kind. The side of the wall which is cool will condense the moisture in the air, absorb it and give it back in vapor on the other side. This fact causes all sorts of trouble in buildings of every description; especially is it so when buildings are new and walls are saturated with moisture and insufficient time is allowed for them to dry out prior to finishing the interior and tenanting them. This phase of the subject was referred to by me in an article on "Damp Proofing," published in The Engineering Record," Feb. 17th, 1906.

In damp-proofing cement walls, I would recommend where a plastic cement mortar is to be used as a finish on the exterior or interior, that in order to prevent a buckling of the finish a mechanical bond be made on plain surfaces or projections, such as metal clips, ties or bonds, embedded into the concrete, to which may be fastened afterwards wire, expanded metal, or bars, etc. The surfaces should then receive one or two coats of damp-resisting paint including all metal used for the mechanical bond and the plastic cement finish can be applied thereon to any thickness with perfect safety. The number of ties or bonds embedded in the concrete will not impair the efficiency of the film of paint as long as it is applied thoroughly and well brushed in around them. This method is illustrated in one of the accompanying sketches.

Damp-resisting paint can be successfully applied in substructures to resist water-pressure. It is put on with specially prepared paper in alternate layers, much in the same manner as tar paper and hot asphaltum and pitch. Its advantages are numerous. Requiring no heat, is always ready and can be handled without danger, which makes places difficult of access, enabling the mechanic to perform the work more carefully and efficiently. The paper used can be nailed on or broken over bonds or ties regardless of making holes in it. The process in general involves pumping a drainage to a sump, as it is now generally done. This waterproofing can be applied successfully on brick work or terra cotta, and its superiority over asphaltum is owing to the fact that in cities where there is gas and sewage or when buildings are close to water into which sewage is discharged it is able to resist the action of sewer gases as well as to exclude the water. The method of applying the paint to resist water-pressure is shown in the second one of the accompanying sketches.

Very truly yours, John B. Clermont.
New York, July 3, 1906.